GUIDEBOOK FOR THE 39th ANNUAL TRI-STATE GEOLOGICAL FIELD CONFERENCE

October 11 & 12, 1975

DEPARTMENT OF GEOLOGY
UNIVERSITY OF IOWA
IOWA CITY, IOWA

TRIP #1: DEVONIAN LIMESTONE FACIES: CEDAR VALLEY AND STATE QUARRY LIMESTONES IN THE IOWA CITY REGION by P.H. Heckel, E.C. Kettenbrink & G. Klapper

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*Figures 1-4 follow text on p. 10

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Compiled by P.H. Heckel

GENERAL CONTENTS

GENERAL ACKNOWLEDGMENTS

We greatly appreciate the aid given by the following persons and organizations in helping us plan and carry out the arrangements necessary to conduct this field conference: N. J. Pickett of the University of Wisconsin at Eau Claire provided extensive information on the 1974 Tri-State Field Conference; the University of Iowa Conference Center handled most of the mailings, registration, guidebook printing, and meals; Marilyn Meade of University of Iowa Geology Department typed the guidebook; and many members of the Iowa University Chapter of Sigma Gamma Epsilon performed a number of necessary chores relating to early mailings, late registration, and driving additional vehicles.

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CEDAR VALLEY LIMESTONE IN EAST CENTRAL IOWA

by E.C. Kettenbrink; edited by P.H. Heckel

Current practice following Stainbrook (1941) divides the Cedar Valley into three members, in ascending order: Solon, Rapid, and Coralville (Fig. 1), all named for localities in Johnson County, Iowa. The divisions were originally defined in terms of faunal zones (mainly brachiopods) established by M.A. Stainbrook over a period of 20 years (see, for example, Stainbrook, 1935, 1941, 1944). More recently determined lithostratigraphic criteria indicate essentially the same member boundaries (Kettenbrink, 1973). Vertical lithologic sequence, sedimentary structures, and paleoecologic associations suggest that the three members of the Cedar Valley were deposited in a distinct succession of environments. This succession is particularly evident in the upper Rapid and Coralville Members, which represent environments progressing from subtidal through supratidal. This environmental sequence is easily recognized in east central Iowa where the formation is predominantly limestone that has undergone little diagenetic alteration. Regional dolomitization and facies changes north of Waterloo, Iowa, however, make environmental interpretation there more difficult, although it has been undertaken in the Waterloo region by Anderson and Wiig (1974).

Stratigraphy and Lithology

Solon Member. - The predominant Solon lithology is brownish thick-bedded to massive, fine-grained skeletal calcarenite. A thin sandstone or sandy calcarenite is present in the base, and often extends downward into the brecciated zone of the underlying Wapsipinicon, where it forms a matrix of stratigraphically leaked material between the clasts as we shall see at Stop 1. The Solon thickens northward from a minimum of 6 feet near Davenport to over 70 feet around Waterloo, Iowa. At most localities the Solon becomes more fine grained upward as it grades into the overlying Rapid. Brachiopods dominate the Solon fauna, particularly in the lower portion of the member. Atrypids and strophomenids are most abundant both in number of taxa and individuals. Less abundant than brachiopods, but frequently found, are echinoderms, corals, bryozoans, stromatoporoids, trilobites, gastropods, nautiloids, and sponges. The upper Solon is characterized by colonial and solitary rugose corals that are abundant enough locally to form biostromes (the profunda zone of Stainbrook, 1935). The Solon biostromes are not laterally extensive, and locally form buildups that have been called bioherms. Hexagonaria, Asterobillingsa, Cystiphylloides, and an unidentified stromatoporoid are the major components. At a few localities, shell accumulations composed almost totally of the terebratulid Rensselandia occur in approximately the same stratigraphic position as do the biostromes elsewhere.

Rapid Member. - This unit is the most commonly exposed, and lithologically most homogeneous member of the Cedar Valley, It is characteristically medium bedded, light bluish-gray, argillaceous skeletal calcilutite with shaly layers in the lower part. The lowest conspicuous shaly layer separates the Rapid from the Solon in Johnson County. Concentrations of disseminated pyrite, partially pyritized fossils, glauconite, and white chert nodules are present in the upper Rapid. Two thin calcarenitic coral-stromatoporoid biostromes, studied in detail by Zawistowski (1971), occur above the middle of the member in Johnson County. The average thickness of the Rapid is 50 feet, and it varies little throughout eastern Iowa. Most of the Rapid is bioturbated and extremely fossiliferous, although nearly barren beds are present. The Rapid fauna outside

the biostromes is dominated by brachiopods. As in the Solon, atrypids and strophomenids are the most abundant and diverse elements. Echinoderms, fistuliporoid and fenestellid bryozoans, phacopid trilobites, several genera of solitary corals, tentaculites, and thamnoporoid tabulate corals are also common. Only a few scattered massive stromatoporoids and favositid corals (but not the colonial rugose coral Hexagonaria) are found outside the biostromes. The Rapid biostromes range in thickness from 2 to 5 feet and are characterized by abundant large heads of Hexagonaria and massive stromatoporoids. They also carry less conspicuous horn corals, massive favositid corals, crinoids, and brachiopods. These accumulations contain sand-size grains of glauconite and the only significant skeletal calcarenite in the member. Both biostromes rest on minor discontinuity surfaces.

Coralville Member. - The Coralville is the thinnest (40 feet maximum), lithologically most diverse, and least frequently exposed member of the Cedar Valley. It is separated from the Rapid by a sharp, often burrowed discontinuity surface, which marks the abrupt change from Rapid calcilutite to Coralville calcarenite. The Coralville has been divided into a lower skeletal calcarenite and an upper laminated and pelleted calcilutite (Kettenbrink, 1973). Colonial corals and massive stromatoporoids are the most important faunal elements in the lower half of the calcarenites, whereas the ramose stromatoporoid, Idiostroma, dominates the upper half of the calcarenites. The maximum concentration of Idiostroma culminates in Johnson County in a 2- to 10-foot thick biostrome, known locally as the "Idiostroma bed." Brachiopods are only a minor element of the Coralville calcarenite fauna.

The upper Coralville is characterized by laminated and pelleted calcilutites with a low clay content. Although generally poorly exposed, this lithofacies contains the greatest variety of rock types, sedimentary structures, and environmentally restricted fossils found anywhere in the Cedar Valley. The thickest (25 feet) and best exposure of this lithofacies is in the River Products-Conklin Quarry (Stop 1), which is also the type section of the Coralville Member. Here, in the western, newer part of the quarry, five lithologic subdivisions of the upper Coralville have been recognized by Kettenbrink (1973). They are, in ascending order: 1) gastropod-oncolite bed; 2) lithographic limestone; 3) Amphipora bed; 4) intraclastic calcilutite to calcirudite bed; and 5) birdseye bed. The well defined environmental sequence at this locality has been used as a reference section for comparison with other upper Coralville sections, which are usually incomplete or poorly exposed. The upper Coralville biota is dominated by large numbers of a few types of environmentally restricted organisms, with the diversity of organisms decreasing upward. Macrofossils are scarce, except for snails and scattered Idiostroma and favositid corals in the gastropod-oncolite bed, and abundant slender cylindrical stromatoporoids in the Amphipora bed. Mutual occurrence of the two most common Cedar Valley "finger" stromatoporoids (Idiostroma and Amphipora) is unusual, probably because each was adapted to different parts of the range of upward increasing environmental stress accompanying shoaling water conditions. Brachiopods and echinoderms, which are abundant elsewhere in the formation, are conspicuously absent in the upper Coralville. Most macrofossils exhibit a thin to thick lamellar coating that consists of microscopic blue-green algal filaments often incorporating ostracodes, foraminifers, worm tubes (Spirorbis), and other unidentified skeletal fragments. Coralville strata above the Amphipora bed are essentially devoid of macrofossils, and the biota consists only of ostracodes,

algae, and foraminifers. These strata are also characterized by sedimentary structures that are characteristic of sedimentation in very shallow water with periodic subaerial exposure. Most noteworthy are solution cavities filled with bedded crystal silt and locally with green clay, multiple horizons of large polygonal mud cracks, microkarst surfaces with associated vadose pisoliths (paleocaliche), and "birdseye" desiccation features.

Depositional Environments

Deposition of the Cedar Valley was initiated by a marine transgression over the underlying Wapsipinicon surface. This transgression incorporated siliceous sand from several sources along with reworked Wapsipinicon fragments into the basal Solon deposit. Continued transgression resulted in continouous depositon of fine to medium-grained muddy skeletal calcarenites, which contain the most diverse assemblage of normal marine organisms found in the formation. The dominant marine organisms: brachiopods, echinoderms, colonial and solitary corals, encrusting stromatoporoids, and bryozoans, along with the abundance of both carbonate mud and sand suggest deposition either side of effective wave base in normal marine water of moderate depth and turbulence. In certain areas late during Solon deposition, occurrence of large "heads" of stromatoporoids, colonial rugose and favositid corals, and scarce algae, along with reduction of mud content, suggest a firmer substrate and lowering of effective wave base in perhaps slightly shallower water that led to formation of the Solon biostromes. The origin of these localized biostromes seems related to response of organisms on pre-existing topographic highs to a slight lowering of effective wave base. The end of Solon deposition was marked by a slowdown or cessation of carbonate sedimentation throughout the basin.

Sedimentation resumed with deposition of the lowest shaly zone of the Rapid argillaceous calcilutites. Abundance of mud sediment and marine organisms and lack of current-induced structures in this lithofacies indicates a marine subtidal environment below effective wave base. However, the paucity of stromatoporoids and horn corals and absence of colonial rugose corals, calcareous algae, and foraminifers, along with local concentrations in some horizons of tentaculites and conularids suggest a somewhat restricted environment. Salinities were probably still normal because the most abundant groups (brachiopods and echinoderms) are thought to have been restricted to normal marine waters as they are today. Increased water depths might alone explain this restriction, but the high argillaceous content suggests additional possibilities. Increased influx of fine detrital material into the basin probably resulted in greater water turbidity that could have restricted corals, stromatoporoids and algae. Abundant argillaceous material also might have produced a substrate too soft to support large colonial organisms. Thus, abundance of mud, presence of echinoderms in an otherwise slightly restricted fauna, and the absence of algae, abraded grains, and spar cemented, cross-bedded calcarenites suggest that Rapid calcilutities are the deepest-water Cedar Valley lithofacies, deposited totally below effective wave base. Deposition was slow and intermittent, and during two periods of non-deposition, large colonial corals and stromatoporoids, conspicuously absent elsewhere in this member, became established on minor discontinuity surfaces. These organisms produced the Rapid biostromes which flourished until the next influx of detrital mud terminated their growth. The end of Rapid deposition was marked by cessation of all sedimentation, which left a burrowed submarine disconformity.

Coralville calcarenites contain a less diverse assemblage of organisms than Solon calcarenites. The Coralville fauna is dominated by corals (colonial rugose and favositids) and stromatoporoids (Stromatopora and Idiostroma) with subordinate amounts of echinoderms. Brachiopods are less abundant, and bryozoans are essentially absent. Previous workers (Laporte, 1967; St. Jean, 1971; Jamieson, 1971) have considered that the environment most favorable for proliferation of colonial favositids and ramose stromatoporoids, such as found in the Idiostroma bed, was shallower and less turbid than that for colonial rugose corals and massive hemispherical stromatoporoids such as found below in the lowermost Coralville. Moreover, the upward increase of both sunlight-dependent calcareous algae and of euryhaline organisms such as ostracodes, gastropods, and blue-green algae, also suggest that Coralville calcarenites were deposited in progressively shallower and more restricted marine waters. Better winnowing of Coralville calcarenites than Solon calcarenites suggests stronger, more pervasive water agitation that would be expected in shallower water.

The biota of the upper Coralville laminated and pelleted calcilutites is dominated by large numbers of a few types of euryhaline organisms such as ostracodes and gastropods, suggesting a very shallow and restricted environment with a wide fluctuation in factors such as salinity. Upward decrease in diversity of organisms reflects increasing restriction of the environment through time. Upward increase of mud content indicates progressive reduction in wave and current activity. In the gastropod-oncolite bed, presence of algal coatings completely surrounding large bioclasts indicates that waves and currents had not yet been damped enough to preclude periodic agitation. They were, however, insufficient to winnow significant quantities of lime mud. The Amphipora bed represents the shallowest portion of a lagoonal regime that supported large numbers of invertebrates. Strata above the Amphipora bed were deposited in even shallower water with salinity and temperature fluctuations too extreme to support life other than certain calcareous algae, foraminifers, and ostracodes. The intertidal environment is probably recorded in the intraclastic calcilutite/calcirudite bed, which contains abundant sediment-perforating algae and intraclasts. The birdseye bed, characterized by an almost complete lack of organisms, by the presence of multiple horizons of large mud cracks, and microkarst surfaces with associated vadose pisoliths, as well as by the spar-filled bubble-like voids that give it its name, was probably deposited completely in the supratidal environment above the level of mean high tide.

Vertical distribution of major Cedar Valley lithofacies, organisms, and sedimentary structures (Fig. 1) demonstrates that the Solon and Rapid Members represent a more or less continuous marine transgression with only minor fluctuations of sea level. The Coralville Member, on the other hand, represents an environmental sequence from subtidal through intertidal to supratidal and thus represents shallowing water with eventual regression of shoreline back across the previous deeper water deposits of the Solon and Rapid Members.

STATE QUARRY LIMESTONE

by P.H. Heckel, largely summarized from Watson (1974)

Greatly more geographically restricted than the Cedar Valley Limestone and found only at certain localities in Johnson County, most of which form a linear pattern (Fig. 3), the State Quarry Limestone had previously been considered to be an erosional channel deposit entirely of post-Cedar Valley age. Recent work by Watson (1974), however, has shown that the State Quarry grades southward at the south edge of its major outcrop belt, exposed along the west shore of the Coralville Reservoir, into the upper beds of the Coralville Member of the Cedar Valley Limestone (Fig. 4). These stratigraphic relations thus make it a channel deposit that was contemporaneous with the late Coralville tidal shoreline deposits, and suggest that the State Quarry is more reasonably considered a member of the Cedar Valley Limestone equivalent to the upper Coralville, rather than a separate formation.

Most known exposures of State Quarry Limestone occupy the outcrop belt of the main channel nearly one mile wide and extending about 5 miles southwestward from the village of Solon; isolated exposures of State Quarry are known several miles to the southeast near the settlement of Newport (Fig. 3). Thickness of the State Quarry reaches nearly 40 feet in the axis of the main channel and decreases both northward and southward toward the edges of the channel (Fig. 4). This trend reflects the amount of down-cutting into the underlying Cedar Valley, which reaches the lower Rapid below the biostromes at places along the axis of the channel as we will see at Meyer Quarry (Stop 4).

The State Quarry consists dominantly of cross-bedded pellet to skeletal calcarenite to calcirudite characterized by abrasion of most skeletal grains. Grain size is greatest at the base along the axis of the channel and decreases both upward and laterally toward the edges of the channel, and also along the channel northeastward toward Solon where pellets become common. Skeletal calcilutite appears at the top of the State Quarry in several exposures, as we will see at Stops 2 and 4. The conspicuous indigenous fauna, as determined by relative lack of abrasion on whole fossils, includes spiriferid, atrypid and rhynchonellid brachiopods, some stromatoporoids, gastropods, and also fish, which provide abundant enough material in places to form bone beds.

The State Quarry Limestone apparently was deposited as the Cedar Valley sea shallowed during late Coralville deposition to the point that currents (perhaps tidal) that previously had swept unhindered across the area began to interfere with the sea bottom. This led to the process of channelization in which the currents became laterally restricted into certain originally slightly lower irregularities in the sea bottom, and with further shallowing began to scour and erode these lows into channels that eventually truncated earlier deposits, down to the lower Rapid in places. The increase in velocity brought about by the lateral restriction of current flow into channels would have enhanced the erosive power of these currents during shoaling. Only the coarsest sediment was deposited along the channel axis where currents were strongest. Finer sediments were deposited along the channel edges and in the northeastern reaches of the channel around Solon, which probably was the shallower shoreward end. As the sea regressed more, the channel shallowed and became choked with sediment, causing currents to weaken to the point that mud could settle out and form the calcilutites that cap the State Quarry in places.

A close modern analogy to the State Quarry channel and contemporaneous upper Coralville tidal shoreline deposits lies along the south shore of the Persian Gulf, where channels averaging 1 mile wide, 12 miles long and 40 feet deep cut modern intertidal and supratidal flats as they join shallow lagoons upon parts of the flats with the main body of the gulf (Heckel, 1972). These channels are filled with carbonate sand (both pellets and skeletal debris) that is washed by diurnal tides. When it is computed that about 40 to 50 feet of lower Coralville and upper Rapid are missing beneath the axis of the main State Quarry channel, which is about 1 mile wide and at least 5 miles long (Fig. 3), the closeness of this analogy in channel size as well as sediments deposited becomes obvious.

On a further note, much younger Pennsylvanian sandstones that presumably are channel deposits are known at places in southeastern Iowa away from the main Pennsylvanian outcrop belt. Two exposures of these occur above the State Quarry in the main channel not far from Mehaffey Bridge (Stop 2), where they apparently represent later fill along a presumably still somewhat topographically low preexisting channel. Another Pennsylvanian sandstone is exposed behind the Mayflower Apartments in the northern outskirts of Iowa City at the same elevation as the lower Coralville and upper Rapid Members of the Cedar Valley are exposed nearby. State Quarry is not known to be exposed here (although the Pennsylvanian-Cedar Valley contact is extensively covered), but a line drawn from this Pennsylvanian exposure to the State Quarry exposure near Newport outside of the main channel is nearly parallel to the main State Quarry channel about 6 miles to the northwest (Fig. 3). The modern Persian Gulf channels are roughly parallel to one another and range from 3 to 15 miles apart. Thus this alignment southeast of the main State Quarry channel may be another Devonian channel in which less State Quarry was deposited or more State Quarry was eroded away toward the southwest during later episodes of water movement, one of which is recorded in the Pennsylvanian sandstone deposit.

CONODONT ZONES AND CORRELATION OF THE CEDAR VALLEY-STATE QUARRY SEQUENCE

by Gilbert Klapper

Four conodont zones that are recognized in the Cedar Valley-State Quarry sequence in eastern Iowa and western Illinois are briefly discussed in ascending order, and their inferred correlation with the standard European zonation is shown in Figure 2.

(1) The *varcus* Zone is identified in the Solon Member (except the uppermost beds) chiefly on the presence of the nominal species, *Polygnathus varcus*, and of *Ozarkodina semialternans*, which first occurs high in the zone both in Europe and near the top of the Tully Limestone (Moravia bed of Heckel, 1973) in New York. The two species are found in the lower Solon Member at Brooks Quarry near Independence, Iowa, and at the type section in Solon Quarry (about 0.5 mile north of Stop 4).

(2) The *hermanni-cristatus* Zone is identified in the uppermost Solon and lower Rapid Members on the first occurrence of *Schmidtognathus wittekindti* and and *Polygnathus* sp. of Ziegler (1966), which is to be formally named in a forthcoming paper. This association probably represents the lower part of the zone and, in the field trip area, occurs at Stops 1, 4, and Solon Quarry.

(3) The insita Fauna, defined by Klapper et al. (1971, p. 300) as the fauna with Pandorinellina insita in strata below the first occurrence of Ancyrodella rotundiloba, presumably correlates with the Lowermost asymmetricus Zone of the standard zonation (Fig. 2), but it apparently represents a specialized biofacies that lacks the zonal indices. East of the Iowa City region, it occurs in the upper Rapid and lowermost Coralville Members at Fancy Creek near Andalusia, Illinois, and at Robinson Creek, 0.5 mile west of Montpelier, Iowa. Within a short distance, 2 miles north of Fancy Creek at the Dewey Quarry near Buffalo, Iowa, the insita Fauna is replaced in the same stratigraphic interval by a different biofacies dominated by Icriodus subterminus and Polygnathus xylus, but also lacking the standard zonal indices. The I. subterminus Fauna occurs in the upper Rapid and lowermost Coralville (below the Idiostroma bed) at Stop 1, but the remainder of the Coralville in this area is barren of conodonts, evidently a response to approaching restricted shoreline environmental conditions. The insita Fauna occurs in the State Quarry Limestone at Stops 2, 3, and 4, and is especially well preserved in the calcilutite facies at Stops 2 and 4.

(4) The Lower asymmetricus Zone, identified on the first occurrence of Ancyrodella rotundiloba, has been recognized only at Fancy Creek (Fig. 2) in the uppermost exposed bed of the Coralville Member (4.2-4.4 feet above the base of the member).

Correlation of the Cedar Valley-State Quarry zonal sequence with central Europe, New York, Nevada, etc., is well understood (Fig. 2). The controversial question of the position of the Middle-Upper Devonian Series boundary, however, is not resolved because definition of the boundary is currently in progress by the International Subcommission on Devonian Stratigraphy. The Subcommission is faced with at least two competing historical definitions of the boundary in the central European sequence: one corresponds to a position high within the varcus Zone (roughly equivalent to the base of the Solon Member) and the other to a position at the base of the Lower asymmetricus Zone (thus, within the youngest part of the Coralville Member at Fancy Creek). Until a definition is reached by international agreement, there is no point in belaboring the position of the Middle-Upper Devonian Series boundary with respect to the Cedar Valley sequence. A rigorous philosophic distinction should be made between the procedure of zonal correlation and the definition of boundaries, as emphasized by McLaren (1970). In the present instance, the correlations are clear, and only definition remains.

THE INDEPENDENCE SHALE PROBLEMS

by Gilbert Klapper

The age and position of the Independence Shale with respect to the Cedar Valley Limestone was historical controversy culminating in the dispute chiefly between M.A. Stainbrook and G.A. Cooper in the 1930's and 40's. Stainbrook (e.g., 1945, p. 2-3; in Cooper et al., 1942, p. 1765-1766) asserted that the Independence was in stratigraphic position below the Cedar Valley (as at the Independence type locality) and correlated the shale with Frasnian (Early Upper Devonian) strata elsewhere. He dated the Cedar Valley chiefly by its assumed position above the Independence, although superposition was the basic issue. Cooper & Warthin (in Cooper et al., 1942, p. 1766-1767, Chart 4) correlated the Independence with late Frasnian strata in New York, and the Cedar Valley with Middle Devonian strata, and argued that the Independence occurs as a

stratigraphic leak within and below the Cedar Valley. Stratigraphic leak of the Independence into various levels of the Cedar Valley-State Quarry sequence can be observed in a sinkhole at Stop 1 (down into the Rapid) and in a cavern at Stop 4 (within the State Quarry). The shale fills several caverns in the Solon Member at Brooks Quarry near Independence, and similar caverns in nearby Pints Quarry at Raymond. Cooper & Warthin's interpretation of the Cedar Valley-Independence relationship is thus supported. The conodonts of the Independence at the cited localities are late Frasnian, specifically Lower and Upper gigas Zones, which are four and five conodont zones younger than the youngest part of the Cedar Valley.

The shale filling the sinkhole and cavern at Stops 1 and 4, as elsewhere, is a jumbled mixture of two shales: a grayish-green clay shale and a dark gray fissile shale. The grayish green-shale at Brooks and Pints Quarries yields delicately preserved Upper Devonian brachiopods, as well as conodonts. Urban (1971, 1972) recovered excellently preserved Late Mississippian (Chesteran) spores and poorly preserved Upper Devonian palynomorphs from one of the caverns at Brooks Quarry. He interpreted the age of the Independence Shale as Late Mississippian, and the Devonian fossils [which must include the brachiopods] as reworked.

An alternative hypothesis is suggested here: (1) the Late Mississippian spores come from the unnamed dark gray shale; (2) the Devonian fossils come from the grayish-green shale, by priority called the Independence Shale (poor preservation of the Devonian palynomorphs is not necessarily due to reworking); and (3) the sinkholes and caverns developed in the Cedar Valley-State Quarry are filled with multiple-generation stratigraphic leaks. One cavern at Brooks quarry is instructive; the green shale lines the walls and the dark gray shale fills the central part of the cavern.

ACKNOWLEDGMENTS

We sincerely thank Tom Scott of River Products Company, Iowa City, for arranging access to the quarries at Stops 1 and 3.

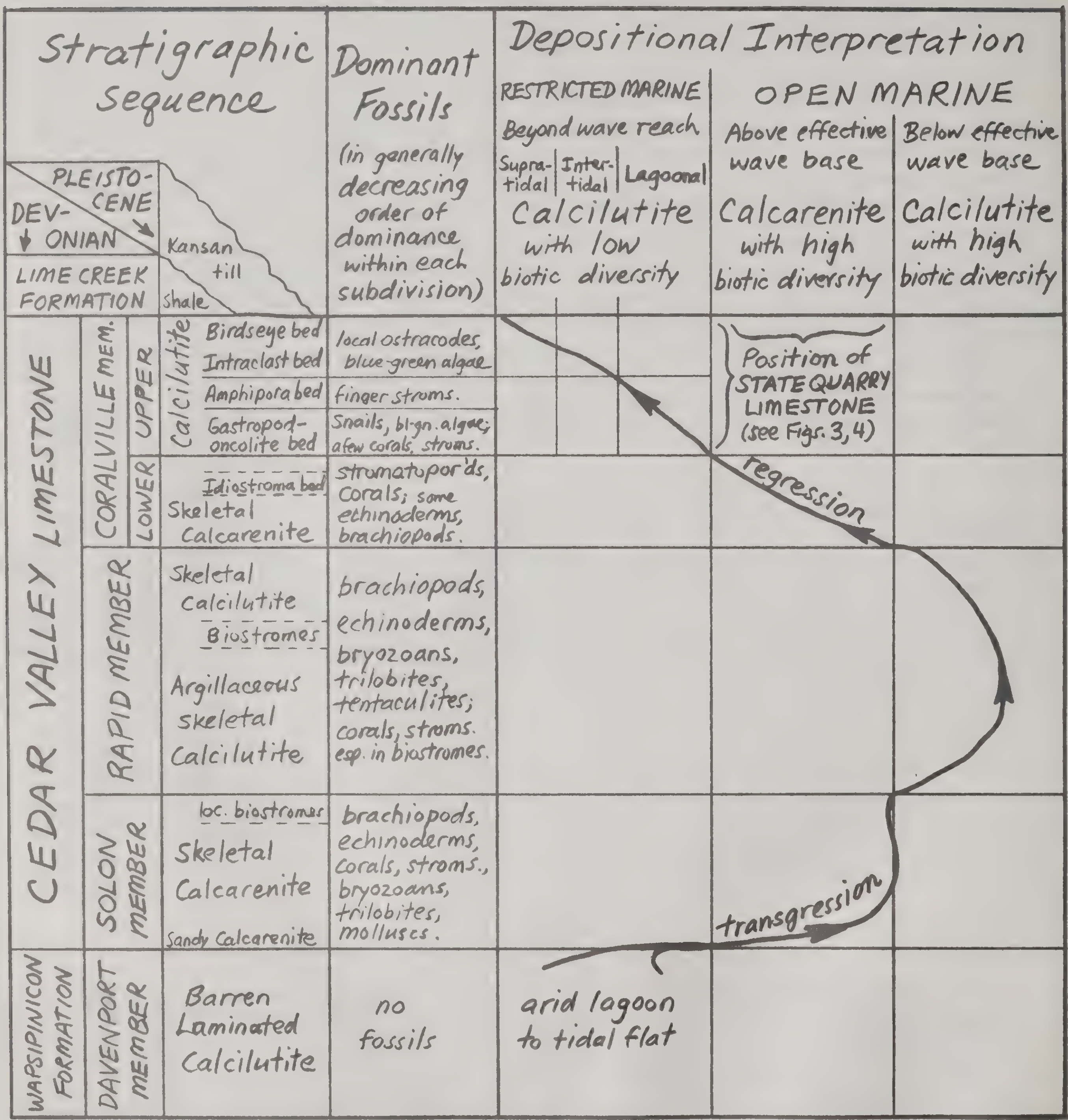


Fig. 1. - Composite section of part of the Devonian sequence in Johnson County, Iowa, showing depositional interpretation of members of the Cedar Valley Limestone and progression of environments through time (modified from Kettenbrink, 1973, p. 166).

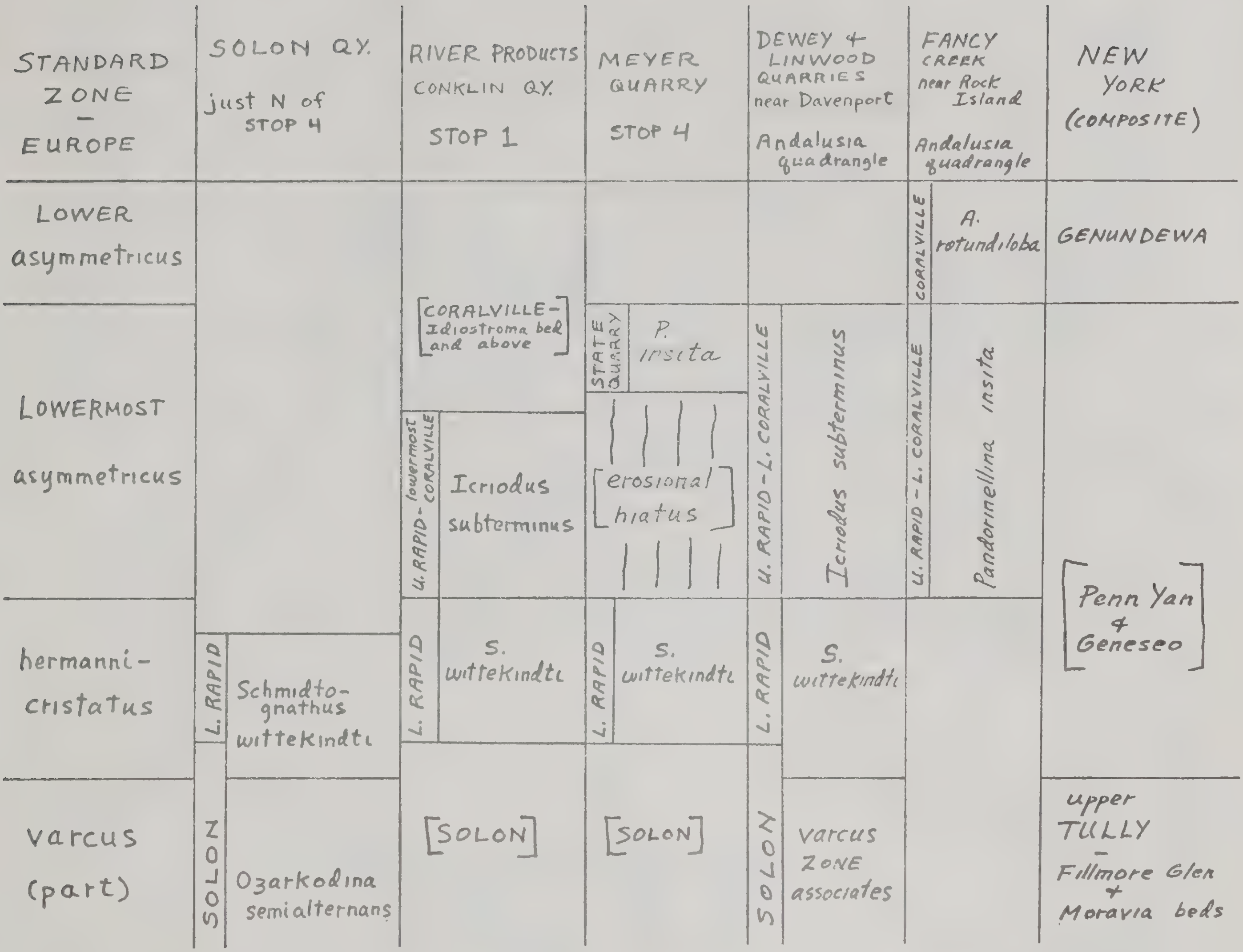


Fig. 2. - Standard European conodont zonation and correlation with the Cedar Valley (Solon, Rapid, and Coralville Members) - State Quarry sequence and New York. Stratigraphic names in brackets denote units from which diagnostic conodont faunas have not yet been published and/or recovered. Equivalence of the insita Fauna at Fancy Creek with the I. subterminus Fauna at Dewey Quarry (2 miles to the north) is supported only by lithostratigraphic criteria, and equivalence of these two faunas with the Lowermost asymmetricus Zone has not been conclusively demonstrated. The State Quarry unconformably lies upon the lower Rapid (below the biostromes) at Stop 4 (on lithostratigraphic evidence), but is equivalent to Coralville strata elsewhere.

Fig. 3. - Map of north central Johnson County showing Cedar Valley Limestone outcrop (from Geological Map of Iowa, 1969, prepared by Iowa Geological Survey), and exposures of State Quarry Limestone (from Watson, 1974, p. 3) and of Pennsylvanian sandstones (supplied by B.F. Glenister).

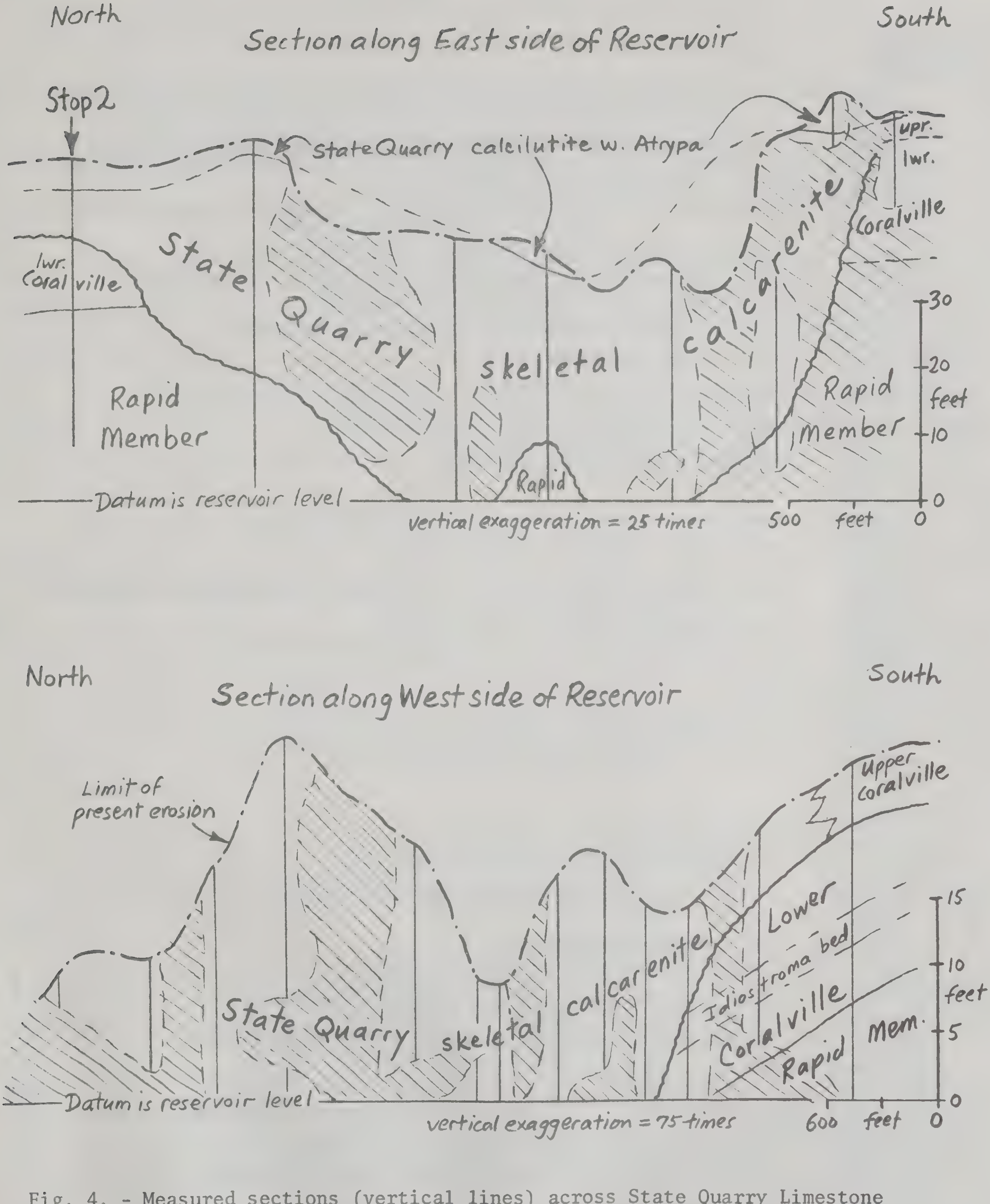
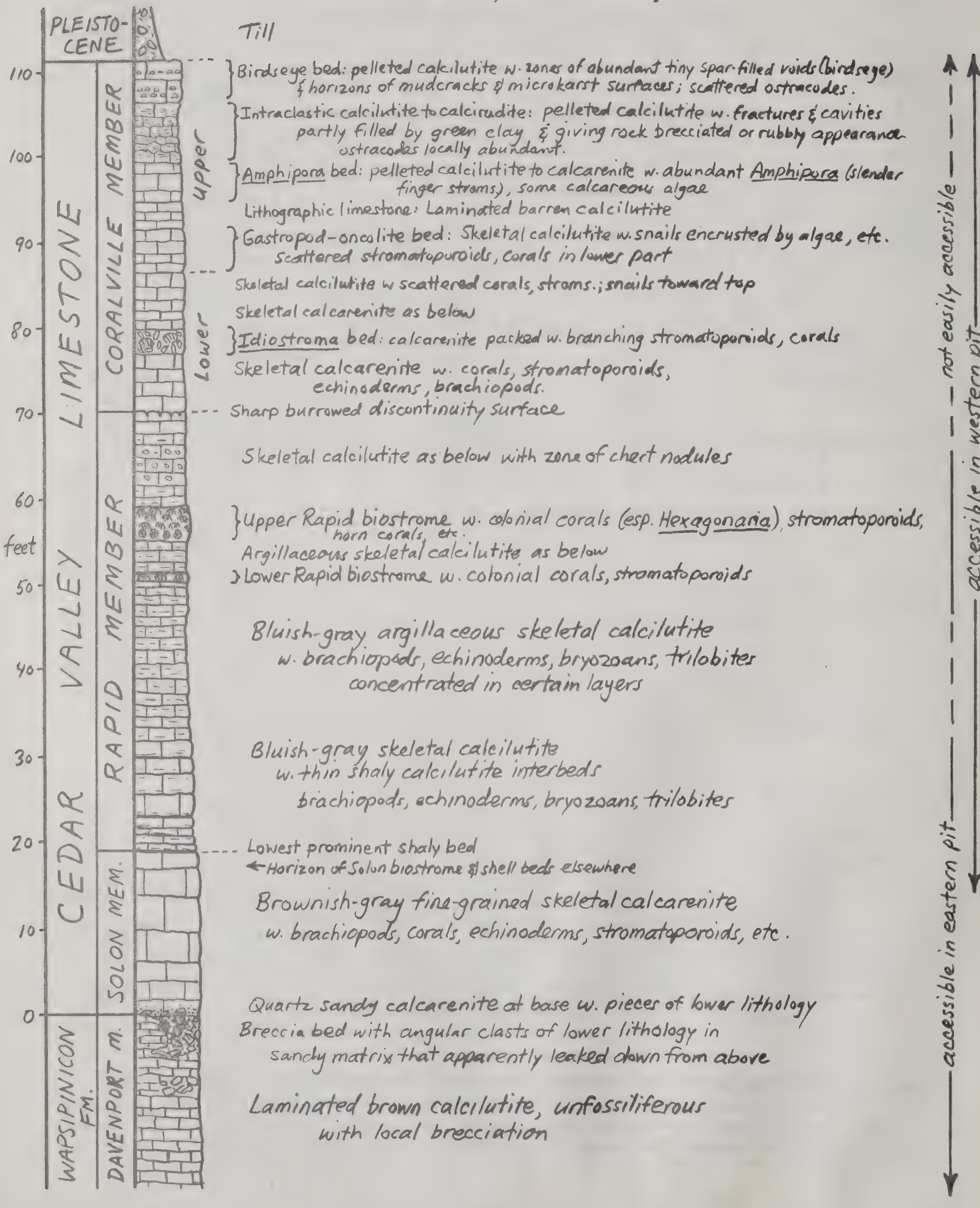


Fig. 4. - Measured sections (vertical lines) across State Quarry Limestone main channel on either side of Coralville Reservoir (slightly modified and simplified from Watson, 1974, pp. 120, 122). Exposure essentially continuous except where lined obliquely.

River Products Conklin Quarry

(redrawn from notes by E.C. Kettenbrink)



BUSES LEAVE I.M.U. AT 8:15 AM

(Back cover shows Stop locations; see also Iowa City West and Ely 7.5' Quadrangles)

STOP 1: River Products Conklin Quarry just north of Iowa City (NW sec 33, T80N, R6W)

This stop shows the complete Cedar Valley Limestone and the top of underlying Wapsipinicon in an area where the State Quarry Limestone is not developed.

Please note that you must sign a release and wear a hardhat in order to be allowed to visit this quarry.

Lowest beds to be visited are in the eastern pit. Davenport Member of Wapsipinicon Formation, a brown laminated barren calcilutite, records deposition in the supratidal shoreline environment. Brecciated zones toward the top probably resulted from collapse during dissolution of evaporites, which are still present in the nearby subsurface. Sandy matrix to breccia has leaked down from basal Cedar Valley (Solon Member) above.

Solon Member of Cedar Valley Limestone with diverse marine fossil content records marine transgression over Wapsipinicon surface with quartz sand as well as pieces of Wapsipinicon worked into the basal deposit. Dominant fine-grained skeletal calcarenite lithology with some carbonate mud records deposition near effective wave base for most of the member.

Rapid Member argillaceous calcilutite with normal marine fauna, but no abraded skeletal grains or cross bedding, records deposition in quiet water below effective wave base along with some clay influx. This indicates further transgression to greater water depths than for the Solon.

Toward the east end of the north wall of the eastern pit is a former sinkhole cutting completely through the Coralville and over half way through the Rapid. It is now completely filled with greenish shale that locally carries younger Devonian conodonts and some dark gray shale that carries Carboniferous spores. Taken together, these shales display multiple episodes of stratigraphic leak down into the Cedar Valley. The greenish shale was found filling a cavern system beneath the Cedar Valley near Independence, Iowa, and, named Independence Shale, it was once thought to be older than the Cedar Valley.

In the western pit, we will see the Rapid biostromes, beds packed with corals and stromatoporoids that record near cessation of mud deposition with development of a hard substrate by small organisms, which provided places of attachment for large encrusting organisms that are nearly absent elsewhere in the Rapid. Common grains of authigenic glauconite attest to slowness of deposition in this part of Rapid. A sharp burrowed surface marks the end of Rapid mud deposition.

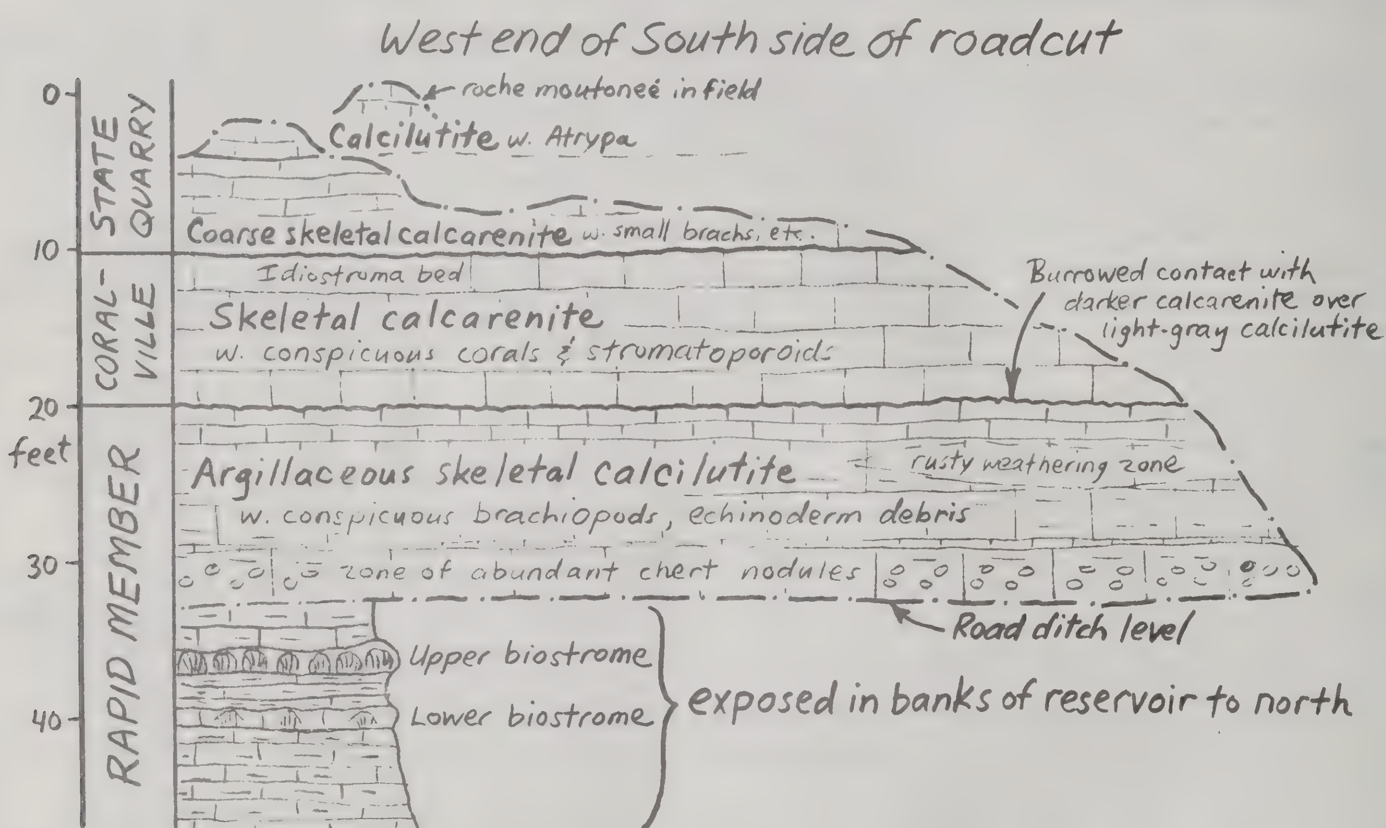
Lower skeletal calcarenites of the Coralville Member with greatly reduced mud content record regression and shallowing of sea above effective wave base with general reestablishment of large corals and stromatoporoids as in the Solon. Upper Coralville calcilutites record return of quiet environments of mud deposition, but reduction of biotic diversity and disappearance of organisms restricted today to normal marine salinities (echinoderms, brachiopods and corals) indicate that these quiet environments were beyond wave reach in protected shoreline lagoons and tidal flats where salinity and other factors often depart from the normal marine range. Furthermore, features such as algal coatings suggest very shallow water, and mud cracks, mud intraclasts, microkarst surfaces, and birdseyes, point strongly to at least intermittent subaerial exposure in the final phase of regression of shoreline across the top of the Cedar Valley.

Leave Stop 1 at 11:30 AM.

STOP 2: Mehaffey Bridge over Coralville Reservoir: roadcut just beyond east end (SW SW sec 33, T81N, R6W) (Lunch will be eaten here.)

This stop shows the upper Rapid and lower Coralville truncated by the State Quarry Limestone near the north side of the main State Quarry channel.

Please note that this area is the Merrill A. Stainbrook State Geological Preserve in which no in-place exposure can be collected. You may collect loose riprap on the causeway or wait until the next two stops.



Rapid argillaceous skeletal calcilutites with abundant echinoderms and brachiopods indicate marine deposition below effective wave base as at Stop 1. Likewise lower Coralville skeletal calcarenite indicates enough regression to bring the sea bottom back into agitated water above wave base.

State Quarry coarse-grained skeletal calcarenite to calcirudite records very agitated water in a laterally constricted marine channel environment formed through this region (Fig. 3) during later regression when upper Coralville supratidal deposits were forming on a partly emergent shoal at Stop 1. Base of State Quarry is erosional, having cut down to the Idiostroma bed through several feet of strata below the State Quarry-equivalent upper Coralville beds. Upper State Quarry skeletal calcilutite with atrypid brachiopods records deposition in quiet yet still marine water resulting when the channel became choked with sediment and shallower later in regression.

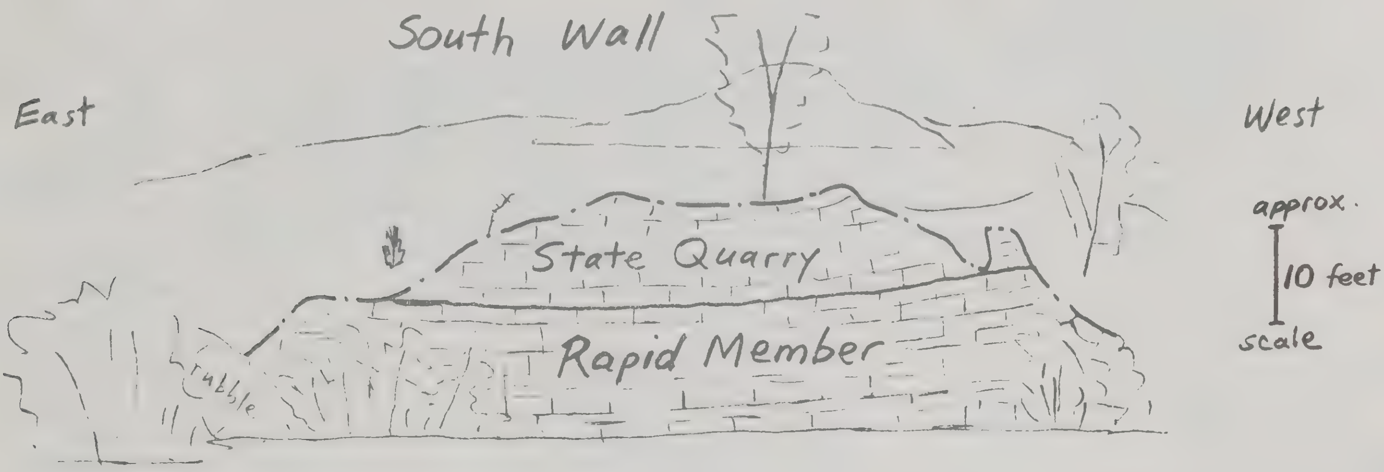
Pennsylvanian sandstone poorly exposed on hill to southwest (across dirt road) records later channel fill in a river that followed the topographic low left by the Devonian marine channel.

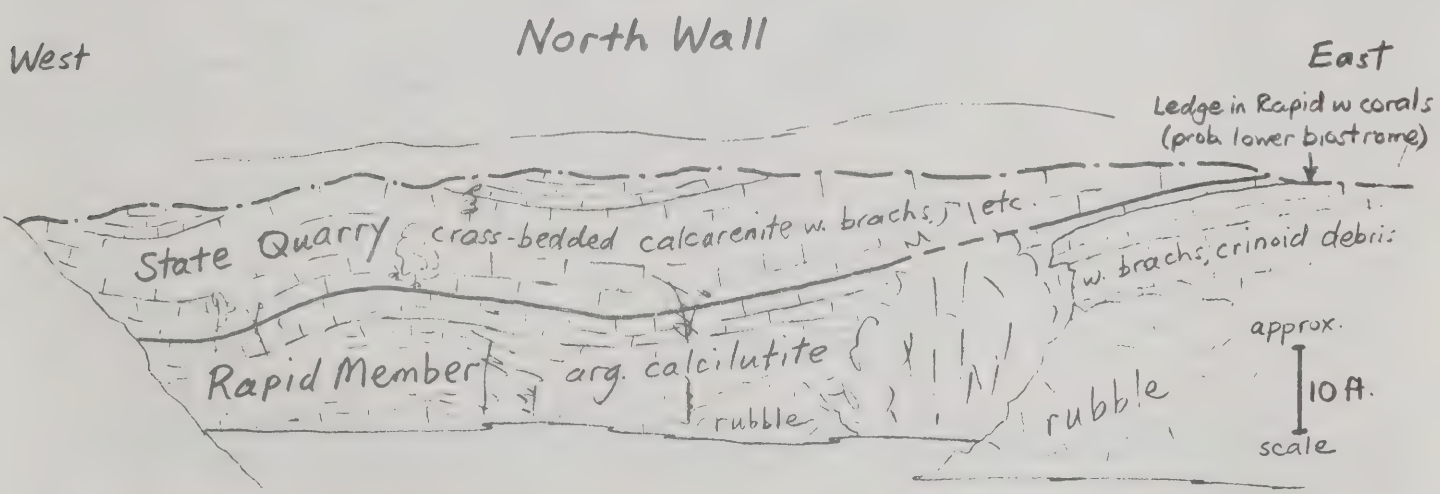
Leave Stop 2 at 2:00 PM.

STOP 3: Vanourney Quarry near Solon (SW SE sec. 26, T81N, R6W)

This stop shows the State Quarry resting on the middle part of the Rapid Member near the axis of the State Quarry channel.

Please stay away from the edges along the top of this quarry because they are not stable and may collapse into the quarry.





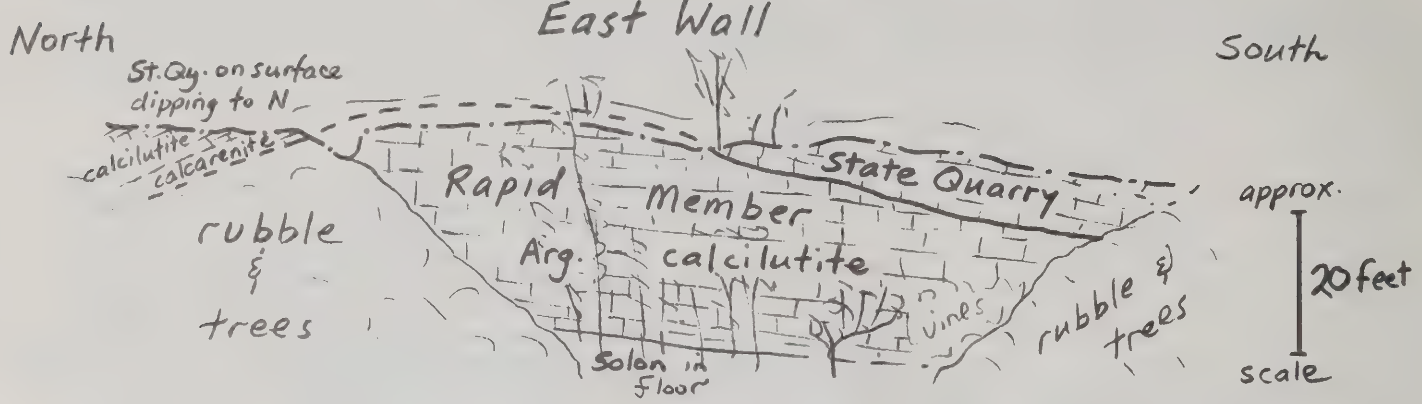
Rapid argillaceous skeletal calcilutite is lithologically like that at Stops 1 and 2, but it lacks the upper part above the lower Rapid biostrome.

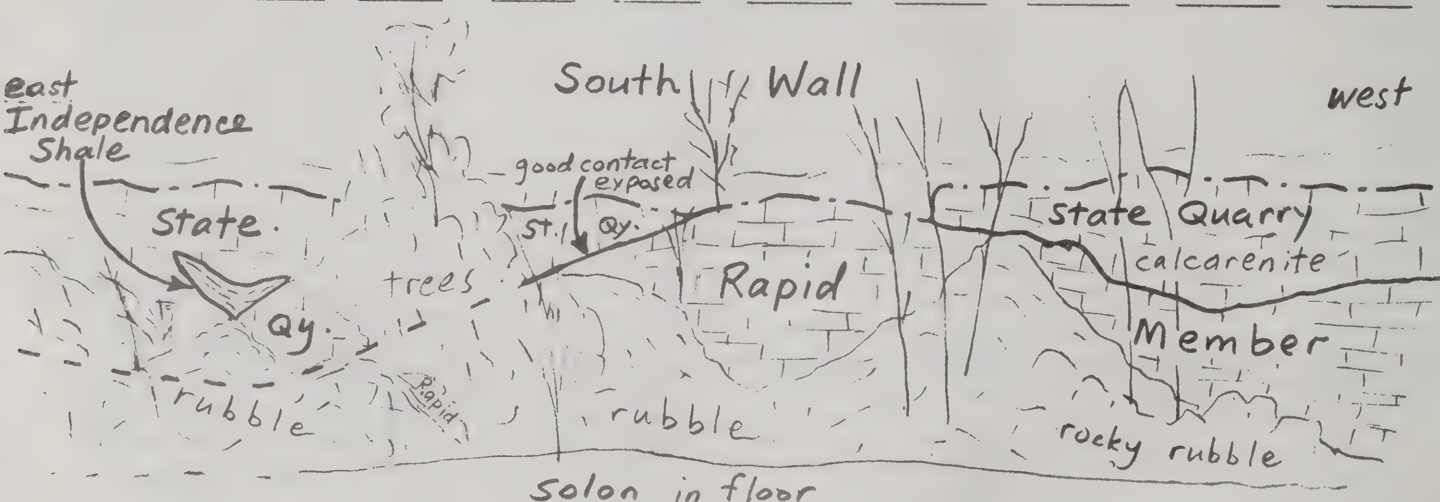
State Quarry pelletal-skeletal calcarenite is thicker than at Stop 2 and records turbulent water near the axis of the channel, which here had eroded entirely through the lower Coralville and about the upper one third of the Rapid. The abrupt basal contact of the State Quarry, however, rests on about the same horizon in the Rapid (just above the lower biostrome) around the entire quarry, which makes it superficially seem conformable here; only observation that the State Quarry rests on different horizons of the Cedar Valley elsewhere gives definite proof that the contact is unconformable.

Leave Stop 3 at 3:20 PM.

STOP 4: Meyer Quarry near Solon (NW NE sec. 26, T81N, R6W)

This stop shows the State Quarry truncating beds in the lower Rapid near the axis of the State Quarry channel.





Typical Solon brownish fine-grained skeletal calcarenite and typical Rapid bluish argillaceous skeletal calcilutite form the base and lower walls, respectively, of this quarry.

Typical State Quarry coarser-grained skeletal calcarenite forms most of the upper quarry walls, with an irregular basal contact that has cut to a level below the lower Rapid biostrome and, dipping southward, truncates beds in the lower Rapid near the east end of the south wall, showing its unconformable nature within a single quarry. A thinner sequence of State Quarry that dips northward in the northeast corner of the quarry grades upward into skeletal calcilutite as at Stop 2.

In the thick State Quarry calcarenite exposed in the south wall is a small former cavern that is now filled with Independence Shale that leaked down from the late Devonian shale sequence, which is now eroded off this part of the outcrop.

Leave Stop 4 at 4:45 PM.

Return to I.M.U. about 5PM; END OF TRIP.

REFERENCES CITED

Anderson, W. I., and Wiig, S.V., 1974, Environment of deposition of the Cedar Valley Formation in the vicinity of Black Hawk County, Iowa: Iowa Acad. Sci. Proc., v. 81, no. 4, p. 135-142.

Cooper, G.A. et al., 1942, Correlation of the Devonian sedimentary formations of North America: Geol. Soc. America Bull., v. 53, p. 1729-1794.

Heckel, P.H., 1972, Pennsylvanian stratigraphic reefs in Kansas, some modern comparisons and implications: Geol. Rundschau, v. 61, no. 2, p. 584-598.

Heckel, P.H., 1973, Nature, origin, and significance of the Tully Limestone, an anomalous unit in the Catskill Delta, Devonian of New York: Geol. Soc. America Spec. Paper 138, 244 p.

Jamieson, E.R., 1971, Paleoecology of Devonian reefs in western Canada: Proc. N. Amer. Paleont. Conv., Chicago, 1969, Part J, p. 1300-1340.

Kettenbrink, E.C., 1973, Depositional and post-depositional history of the Devonian Cedar Valley Formation, east-central Iowa: unpub. Ph.D. dissertation, Univ. of Iowa, 191 p.

Klapper, G. et al., 1971, North American Devonian conodont biostratigraphy, in Symposium on Conodont Biostratigraphy, Sweet, W.C. & Bergström, S.M., eds.: Geol. Soc. America Mem. 127, p. 285-316.

Laporte, L.F., 1967, Carbonate deposition near mean sea-level and resultant facies mosaic: Manlius Formation (Lower Devonian) of New York State: Bull. Am. Assoc. Petroleum Geologists, v. 51, p. 73-101.

McLaren, D.J., 1970: Presidential address: Time, Life and Boundaries: Jour. Paleont., v. 44, p. 801-815.

St. Jean, J., Jr., 1971, Paleobiologic considerations of reef stromatoporoids: Proc. N. Amer. Paleont. Conv., Chicago, 1969, Part J, p. 1389-1429.

Stainbrook, M.A., 1935, Stratigraphy of the Devonian of the Upper Mississippi Valley: Kansas Geol. Soc. Guidebook, 9th Annual Field Conf., p. 248-260.

Stainbrook, M.A., 1941, Biotic analysis of Owen's Cedar Valley limestones: Pan Amer. Geologist, v. 75, p. 321-327.

Stainbrook, M.A., 1944, The Devonian System in Iowa, in Symposium on Devonian Stratigraphy: Illinois State Geol. Survey Bull. 68, p. 182-188.

Stainbrook, M.A., 1945, Brachiopoda of the Independence Shale of Iowa: Geol. Soc. America Mem. 14, 74 p.

Urban, J.B., 1971, Palynology and the Independence Shale of Iowa: Bull. Am. Paleont., v. 60, no. 266, p. 103-189.

Urban, J.B., 1972, The Independence Shale: A palynologic viewpoint: 36th Ann. Tri-State Geol. Field Conference Guidebook, p. 48-52.

Watson, M.G., 1974, Stratigraphy and environment of deposition of the State Quarry Limestone, Johnson County, Iowa: unpub. M.S. thesis, Univ. of Iowa, 140 p.

Zawistowski, S.J., 1971, Biostromes in the Rapid Member of the Cedar Valley Limestone (Devonian) in east-central Iowa: unpub. M.S. thesis, Univ. of Iowa, 120 p.

Ziegler, W., 1966, Eine Verfeinerung der Conodontengliederung an der Grenze Mittel-/Oberdevon, in Das Mitteldevon des Rheinischen Schiefergebirges: Fortschr. Geol. Rheinld. u. Westf., v. 9, p. 647-676.

TRIP #2: STRIP MINE RECLAMATION IN SOUTH-CENTRAL IOWA
(L. Drake & T. Ririe)

CONTENTS

TRIP #2: STRIP MINE RECLAMATION IN SOUTH-CENTRAL IOWA

Guidebook by Lon Drake & Todd Ririe (UI).
Information graciously supplied by Lyle Sendlein (ISU),
Marvin Ross (Iowa Conservation Commission) and Marcy Pavlik (UI).

PURPOSE OF FIELD TRIP

The largest concentration of known coal reserves in Iowa is in the vicinity of the common junction of Marion, Mahaska and Monroe Counties. This area provides a realistic setting for evaluating various reclamation techniques in Iowa. The three sites to be visited here today will each demonstrate a different approach to reclamation research in Iowa:

1. Hull Site - stabilization using trees, shrubs and grasses; tour by Ririe and Drake.

2. Van Zee Site - loess terrace method for production of agricultural land; tour by Ririe and Drake.

3. Scott Site - integrated mining and reclamation projects; tour by Sendlein.

BUS SCHEDULE

8:00 to 9:30 -- Drive to Oskaloosa
9:30 to 9:45 -- Rest stop Oskaloosa City Park
9:45 to 10:00 -- Drive to Stop 1
10:00 to 11:00 -- Stop 1 - HULL SITE
11:00 to 11:20 -- Drive to Stop 2
11:20 to 12:10 -- Stop 2 - VAN ZEE SITE
12:10 to 12:20 -- Drive to Oskaloosa
12:20 to 1:05 -- Box lunch Oskaloosa City Park
1:05 to 1:25 -- Drive to Stop 3
1:25 to 2:50 -- Stop 3 -- SCOTT SITE
2:50 to 3:10 -- Drive to Oskaloosa
3:10 to 3:25 -- Rest stop Oskaloosa
3:25 to 5:00 -- Drive to Iowa City

PHILOSOPHY AND GOALS OF IOWA RECLAMATION

When viewed in an historical perspective, the development of these three reclamation research projects reflects the growth of public interest in energy and the environment. In the mid 1960's, environmental issues began to attract public attention. During this time coal mining in Iowa was viewed as a minor industry where the main reclamation goals were stabilizing erosion and developing wildlife habitat from the spoil banks. In 1967 the state legislature provided funds for experimental strip mine reclamation at the Hull Site (Stop 1) including reshaping the topography and planting trees, shrubs, and grasses.

By the late 1960's some began to recognize the constraints of an ever increasing energy consumption and for Iowa the trade-off between agriculture and coal, but the public was still not interested in investing in environmental projects. The loess terrace method (Stop 2) was designed in 1972 to determine the minimum amount of reclamation necessary to return strip mined land to row crop production. The project was sponsored by Iowa Power and Light (and others) in 1974.

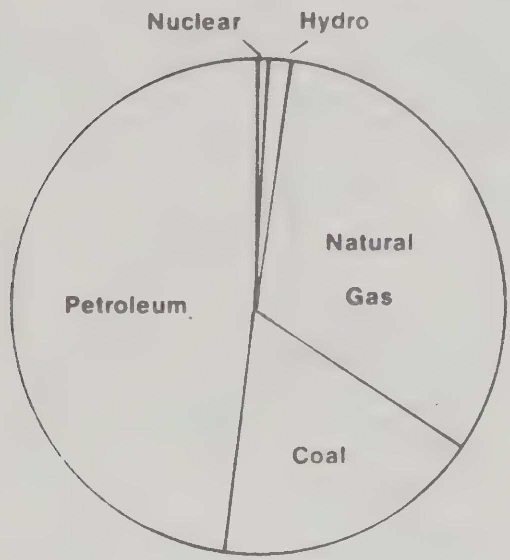
The shortages of gasoline and petroleum-based products in 1973 and 1974 dramatically increased public awareness of the trade-offs between energy, environment, agriculture and population. Environmental costs were no longer viewed separately, but became blended into the inflationary spiral. Iowa State University formed the Energy and Mineral Resources Research Institute (EMRRI) and their program for an experimental strip mine (Stop 3) was funded in 1974 by the State Legislature to study mining methods and reclamation, coal beneficiation, economics, and social trade-offs.

All these projects are producing useful data which will be needed to help Iowa intelligently manage the trade-off between energy, the environment, and agriculture.

ENERGY IN THE USA

Our annual energy consumption in the USA in recent years is estimated at about 70×10^{15} BTU. This is about 340 million BTU's per person (the energy equivalent to burning 14 tons of high grade coal). Most of this energy is derived from fossil fuels, 80% is from petroleum products and natural gas

while coal supplies only 20%. Yet this country's proven coal energy reserves have an energy content nine times as great as that of its petroleum and natural gas reserves.



U.S.
(70×10^{15} Btu)

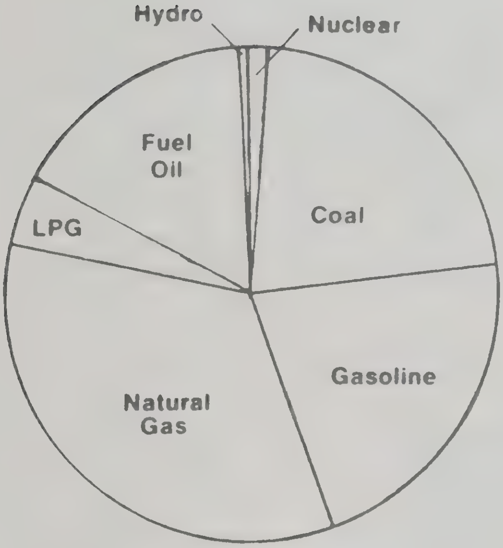
It has been brought forcibly to public attention in the past two years that (1) U.S. proved and potential gas and oil reserves are limited; (2) the U.S. is a net importer of oil with prices controlled by international cartels; (3) oil and oil-derived products are accordingly becoming more expensive; and (4) natural gas will become more expensive and in short supply. Hence there is a strong incentive to replace oil and gas, to the extent practicable, with alternative energy sources. In the short range, conservation and the replacement of oil and gas with coal seem to be the most practical alternatives to shortages in high energy prices. The federal government is mounting a major energy program in fossil fuel research and development. This program places special emphasis on the development of processes for the liquefaction and gasification of coal, and aims for large-scale (about $500 million each) demonstration plants for one or more of each type in operation by 1985 at the latest.

Major Coal Regions

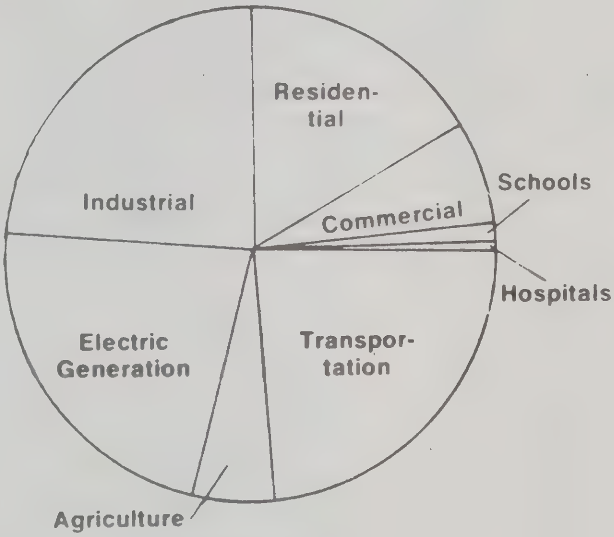
ENERGY IN IOWA

The energy situation in Iowa is similar to that of the nation as a whole, but we are even more strongly dependent on oil and natural gas, with 84% of our energy derived from these two fuels and 16% from coal. Paradoxically, Iowa's fossil fuel resources are almost exclusively coal.

Iowa's per capita energy consumption of 299 million BTU (equivalent to the energy produced by burning 12.5 tons of high grade coal) is slightly below the national average. The Iowa source and function distribution pattern strongly resembles the national pattern. On a per capita basis, Iowans consume somewhat less energy for industry and electrical generation and somewhat more for transportation. The distribution of this consumption by energy source and major end use is shown below:



Fuel Use - By Fuel



Fuel Use - By User

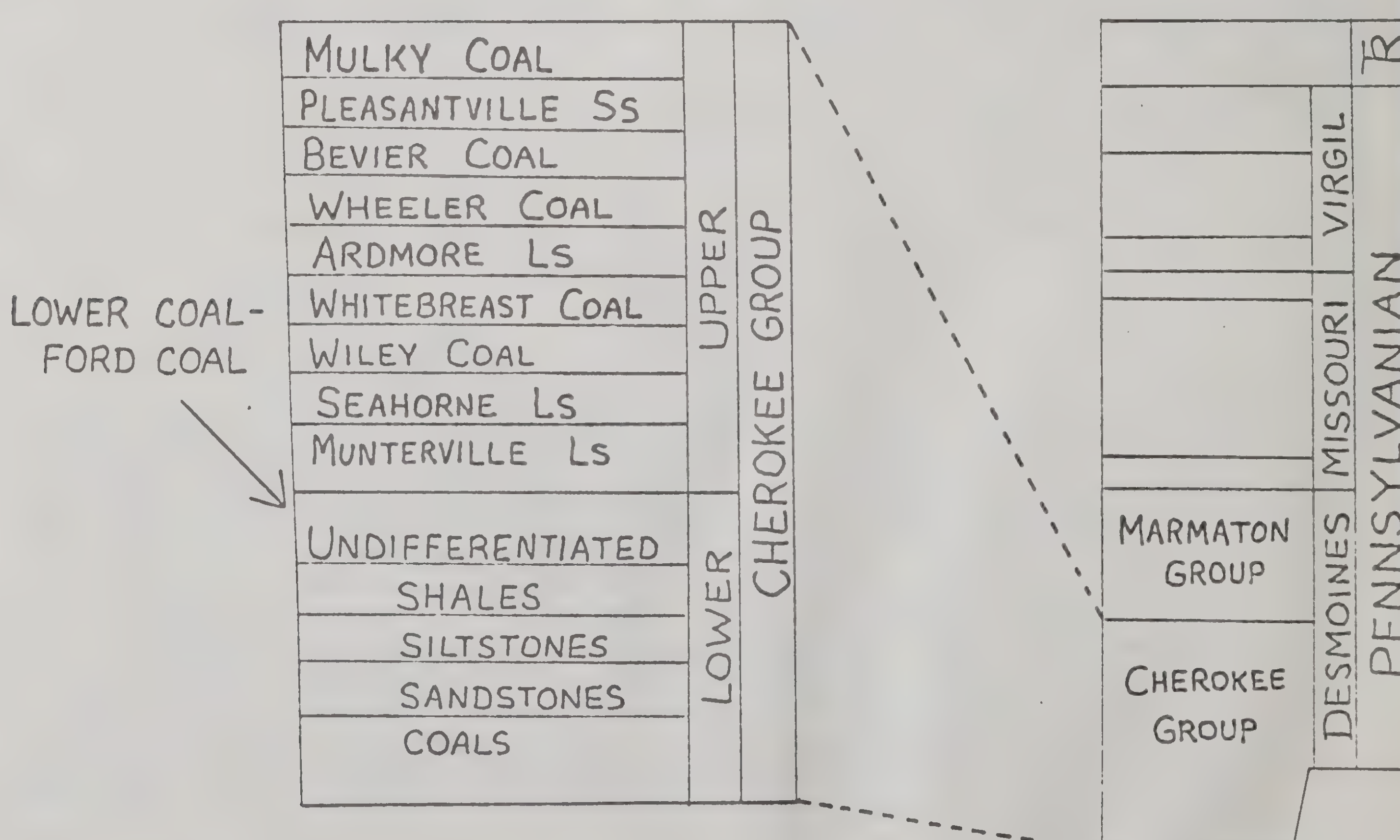
IOWA FUEL USE (1973)

In the short range there is no practical way to substitute anything for gasoline or diesel fuel in the transportation sector (which accounts for 31% of Iowa energy consumption). There is no cheap way to substitute for oil and gas in residential and commercial heating units designed to burn these fuels; 25% of Iowa's energy usage appears to be of this character. Substitution of coal for natural gas in electricity generation and industry, in most cases where equipment is designed to burn either fuel, appears to be the most feasible short range strategy for reducing natural gas consumption. Favorable rates for interruptible natural gas have led to extensive multiple fuel installations in the industrial and electricity generation sectors. Discontinuation of gas supply to interruptible users appears imminent (probably in 1978 according to plans already announced by Northern Natural Gas Company). Substitution of alternative fuels in this case will be forced.

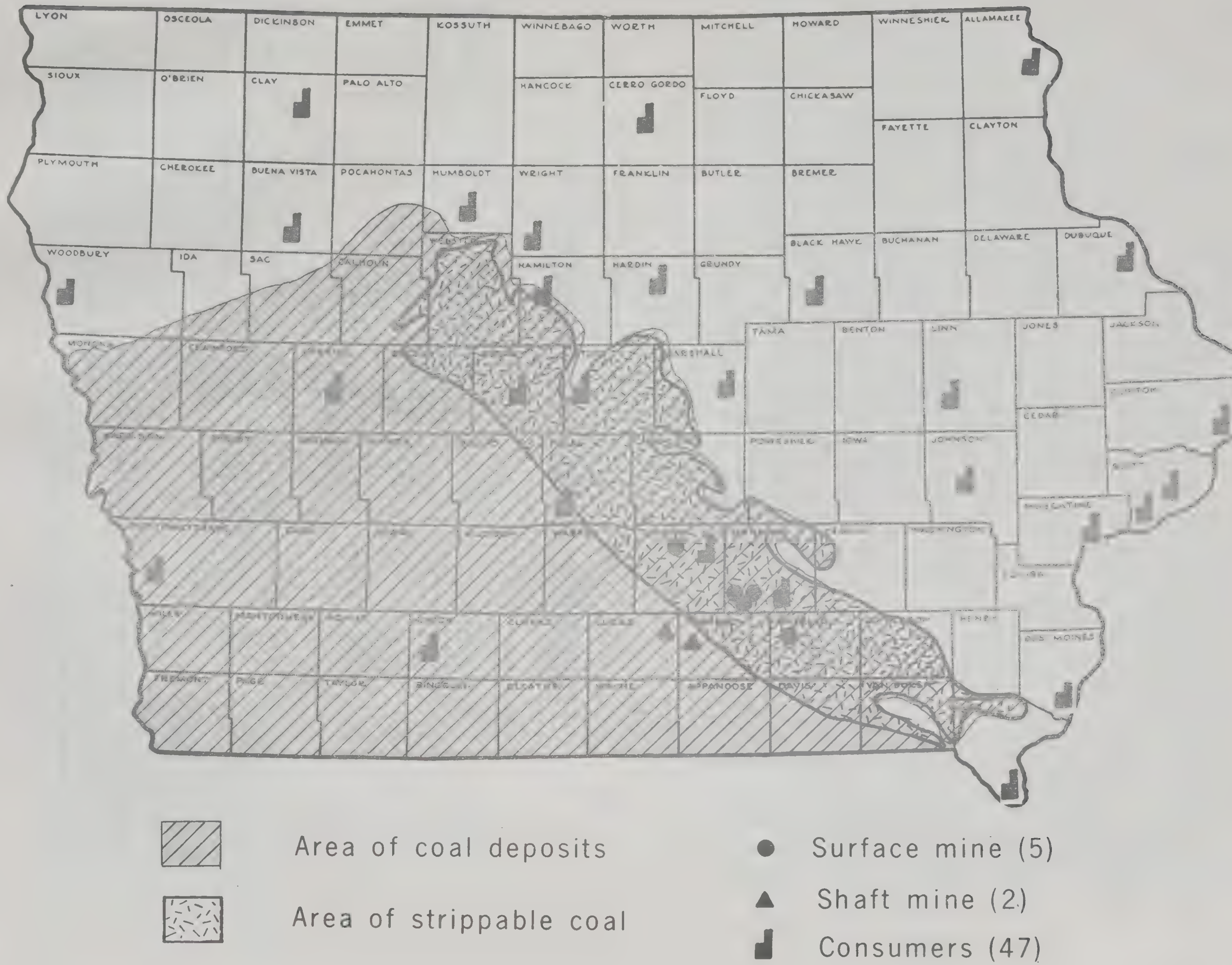
IOWA COAL

Although only 16% of Iowa's energy is furnished by coal, and Iowa's coal reserves are substantial, over 85% of the coal burned in Iowa is imported from other states. Many legislators supporting the coal research project bill, Senate File 1362, plainly hoped that this project would stimulate the redevelopment of an Iowa coal industry which in 1917 employed about 18,000 people, but now employs less than 100. At one time there were about 450 operating coal mines in Iowa. Today there remain two deep shaft mines and five surface (strip) mines in operation. In 1973, about 800,000 tons of coal were mined in Iowa. In the same year about 6,000,000 tons of coal were imported from other states to supply the Iowa power utilities and other industry. The locations of current mining operations and major consumers are shown on the next page.

Iowa coal horizons are relatively small lens shaped deposits which may vary in size from a few acres to a few square miles. Typical deposits are three to four feet thick, contain 3-8% sulfur, and leave 15-20% ash residue when burned. When analyzed optically it contains 67% macerals, 15% mineral matter, and 18% carbargilite, carbankerite or carbopyrite. It is high volitile C bituminous coal with an average heat value of 10,000-11,000 BTU/ton. The basal coal presently being mined in Iowa dips slightly (several ft./mile) to the SW and has been locally termed the "Lower Coal" or "Ford Coal." This coal is representative of horizons stratigraphically adjacent to the boundary between the lower and upper divisions of the Cherokee Group of the Des Moines Series of the Lower Pennsylvanian.



IOWA COAL MINES and MAJOR COAL CONSUMERS



Coal bearing rocks of Pennsylvanian age underlie about 20,000 square miles in the south central part of the state, or approximately 37% of the total area of the State of Iowa. Available data permit estimation of total coal reserves for about 2,056 square miles that cannot be quantitatively evaluated, but possibly contain coal beds of minable thickness. Remaining reserves are calculated by Landis at approximately 6,524 million tons, of which about 3,262 million tons are recoverable by various mining techniques. The Bureau of Mines estimates that about 180 million to 1,000 million tons of "strippable" coal remain in Iowa (this is coal lying less than 100 feet under the ground surface, much more coal may be found at depths of 100 feet or more). Some comparative characteristics and costs of coal are shown on the next page.

A typical Iowa strip mine uses a dragline for removing overburden, together with front-end loaders, bulldozers, and trucks. The removal and careful replacement of topsoil, together with a leveling of the spoil banks, have received attention only in recent years, but has been done successfully in a number of coal fields in other states. One of the serious problems in mining Iowa coal is that the shale overburden is rich in sulfur minerals, which, when exposed to air and water, forms acid injurious to plant and aquatic life. New and different methods which permit replacing the overburden strata in ways that do not allow high-sulfur material to lie on top are necessary if Iowa land is to be returned to agriculture. Overall, the need is to restore the land in forms most suitable to the needs of a particular region which may include crop and pasture production and recreational or wildlife use.

COMPARISON OF COAL CHARACTERISTICS

(As received in Ames, Iowa; January 1, 1975)

SOURCE	AVERAGE HEATING VALUE Btu/pound	SULFUR CONTENT %	COST PER TON* at Mine	Transportation	TOTAL	$/MBTU
WYOMING[1]	9,300	about 0.5	$ 8.30	$ 12.28	$ 20.58	1.11
KANSAS[2]	12,000	4	16.30	7.81	24.11	1.00
UTAH[3]	11,750	about 0.7	12.90	13.97	26.87	1.14
IOWA[4]	9,300	4 to 6	10.40	5.00	15.40	0.83
IOWA (REFINED)[5]	11,000 [6]	less than 3 [6]	15.00[6]	5.00	20.00	0.91

1/ Big Horn Mine; Sheridan, Wyoming

2/ Garland Mine; Garland, Kansas

3/ Plateau Mine; Price, Utah (as of April 2, 1974)

4/ Mich Mine; Eddyville, Iowa

5/ Target characteristics and costs

6/ Includes coal cleaning and land restoration costs

* Railroads have allowed up to $4.00/ton reductions in transportation costs for unit train shipments from Wyoming.

STOP #1 - HULL SITE

In 1967, the 62nd General Assembly appropriated $30,000 to the Department of Mines and Minerals to demonstrate methods of rehabilitating strip mined land, Iowa State University's Center for Industrial Research and Service (CIRAS) subcontracted the mapping and planning (Lyle Sendlein in charge). A portion of the Hull Site was selected which had a complex topography where stripping had been done during the 1930's around older underground mine spoil piles (photo next page). Reshaping this area to gentle slopes was done in 1968 (second photo). The area was fertilized and limed at various rates and planted to a nurse crop of oats to retard erosion. The following spring, a variety of trees, shrubs and grasses were planted under the direction of Marvin Ross.

The first year's growth appeared successful for most species, but in subsequent years many species have died off. Patches of very acid spoil (often referred to as "hot spots") became sharply delineated by their lack of vegetation. The number of surviving species stabilized about 1972-1973, and since then a few of the most tolerant have begun to invade the smaller barren zones. In large barren zones, erosion remains rapid by preventing seeds from stabilizing the area, thus exposing fresh acid material and perpetrating the erosion.

The approximate maximum acid tolerance of various species at the Hull Site is outlined below:

pH 3.5 - 4.0	Arnot bristly locust Three awn (poverty grass)
pH 4.0 - 4.5	Virginia pine Ash (green?) Red pine Tall fescue Crownvetch Brome Black locust
pH 4.5 - 5.0	Soft maples Cottonwood White pine Timothy Sudan grass Redtop Serecia lespedeza Scotch pine

These pH tolerances are only approximate because survival is also influenced by water supply, nutrients, shade, animal browsing, insects, disease, competition and toxic elements. Some individuals may survive planting in conditions more acid than listed, but exist as runts or dwarfs unable to reproduce or spread.

In some places at the ungraded Hull Site the spoils at the surface were only slightly acid (loess, till and/or non-sulphurous shale). These areas were colonized decades ago by pioneer native species and some of the larger patches were left intact during the 1968 reshaping. These now contain large trees, abundant shrubs and wildlife, and a topsoil is beginning to develop in some places. Here, almost any tree, shrub, or grass from a temperate climate will probably grow.

The Hull Site reclamation has been monitored by Marvin Ross (State Mine Inspector) since 1968. He has continued to rework and replant the more difficult areas by hand, with the goal of eventually revegetating the entire surface of the reclamation plot. This project area has now become largely stabilized and is supporting an increasingly diverse biota.

HULL SITE BEFORE GRADING

HULL SITE AS GRADING NEARS COMPLETION

STOP #2 - VAN ZEE SITE

If consumption of Iowa coal is going to increase, then there is a need to design methods to return spoil piles to agricultural land. Lon Drake and Todd Ririe (University of Iowa) designed a loess terrace method (illustrated next page) as a minimum cost approach to return the land to row crop agriculture while strip mining. If substantial yields can be obtained from the loess covered terraces then the value of the new land can be used to help offset the reclamation costs and make the method economically attractive to mining companies. It is estimated that if 18"-24" of loess can be rejuvinated into an adequate "soil" then the increased land value could compensate for about 2/3 of the additional reclamation costs.

The largest unknown for the loess terrace method is the thickness of loess required to produce adequate row crop yields. A $10,000 grant from Iowa Power and Light, Iowa Southern Utilities and University Avenue Coal Company sponsored the project, begun in 1974 to evaluate this variable.

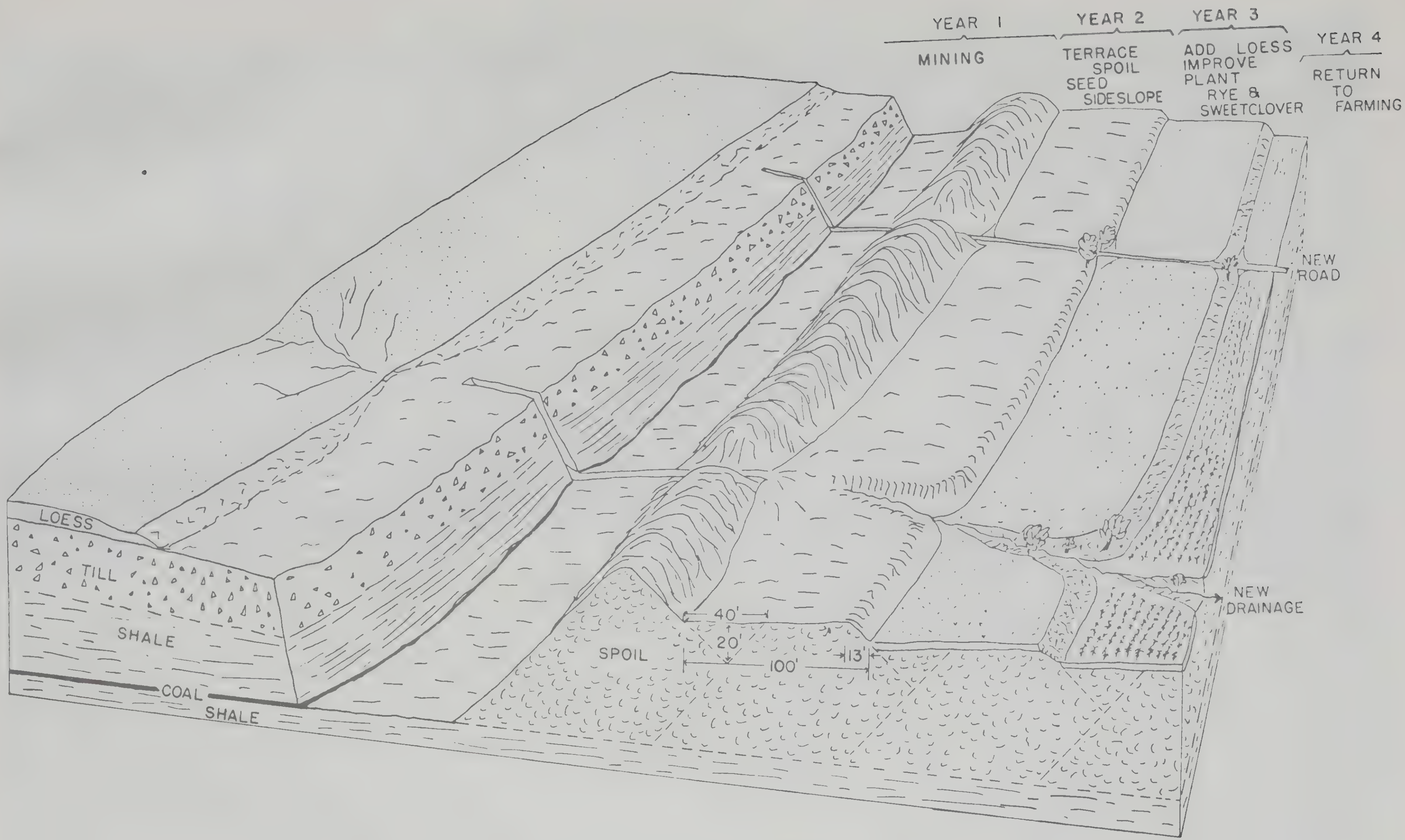
A 1 1/4 acre plot of spoils was leveled and 1 acre covered with a wedge of loess, tapering in thickness from 0" to 36". The loess was removed from an adjacent (unmined) area. Corn has been planted for two years on the loess terrace, the loess-stripped area (thick loess still remains) and on the adjacent Van Zee farm. All the plots were treated as normal corn fields throughout the growing season, receiving identical management (project data follows this text).

Results

The 1974 planting was made in compacted loess which was only deep disced in order to evaluate the significance of compaction. The east end of the loess wedge contains the thickest loess and this end was also used as a haulage road and became more compacted. The midsection of the wedge received less compaction and supported the best stand of corn. Maximum yields for the test plot in 1974 were also obtained from the 18"-24" of loess (harvest data follows this text). Plants throughout the test plot showed a predominantly shallow and horizontal root growth which componded the effects of the drought. Most of the roots were in 3 or 4 flat horizontal clusters in the platy cleavage of the compacted loess. Late planting, early frost and retarded growth rate resulted in immature corn which reduced yields. Iowa State University agronomists suggested the corn also appeared deficient in nitrogen.

Winter freeze-thaw, followed by chisle plowing in early spring reduced compaction. Using a pocket penetrometer the average compaction over the test plot (at all depths) dropped from 3.2 tons/ft.^{2} in summer 1974 to 2.0 tons/ft.^{2} in summer 1975. However, during this same time average acidity increased from pH 5.8 to pH 5.2. Plant growth in 1975 at the thick loess end of the wedge is slightly better than the midwedge section indicating that the frost action-chisle plowing combination alleviated the most serious compaction.

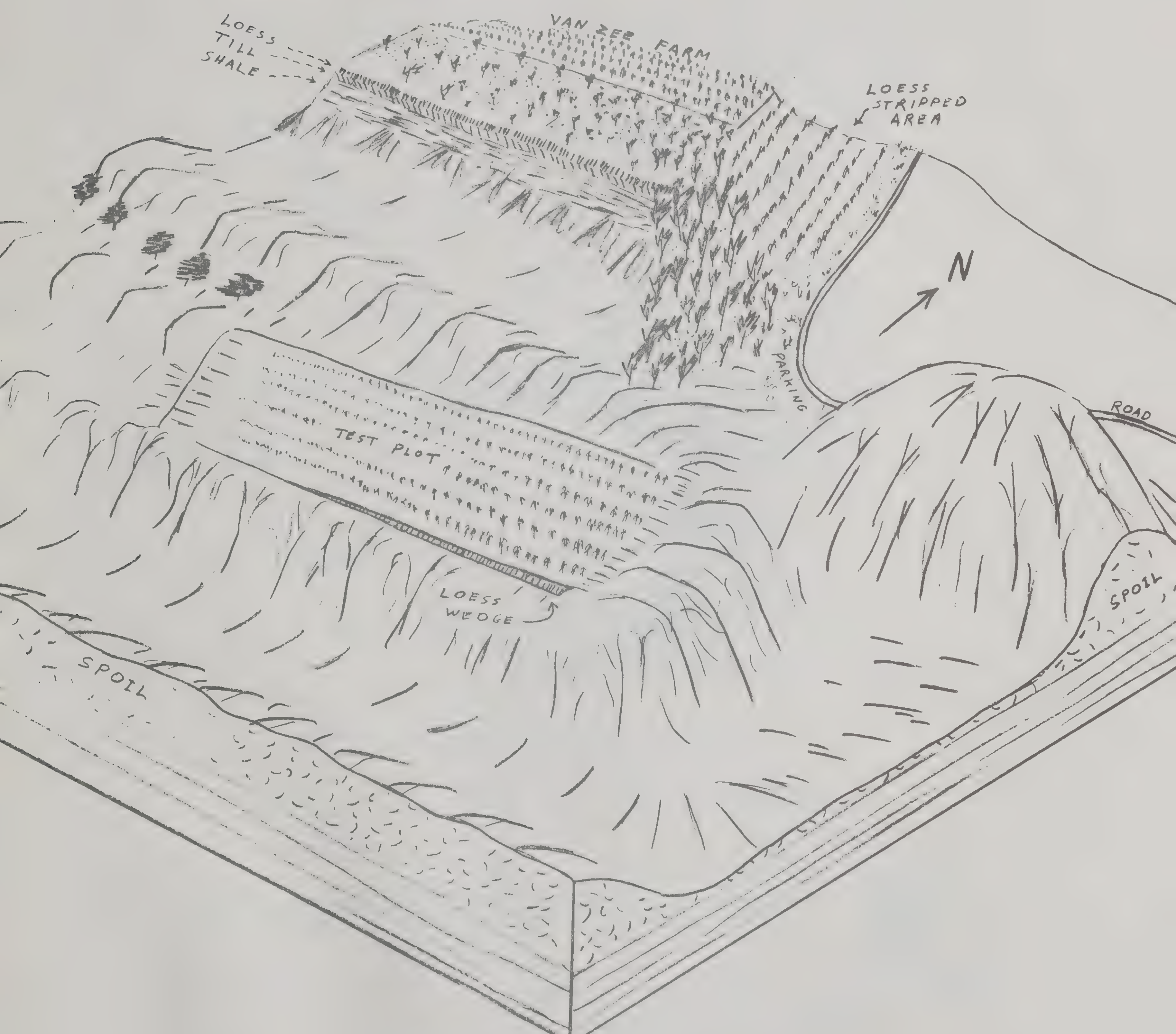
The six week drought of midsummer began well before and continued through the pollination period of the test plot corn. Many portions of the plot failed to pollinate while other portions nearby have well developed ears. The reasons for this disparity are not known but some combination of organic content, acidity & compaction are suspected. This will be tested after the dimensions of these patches are delineated by yield data.



A LOESS TERRACE METHOD

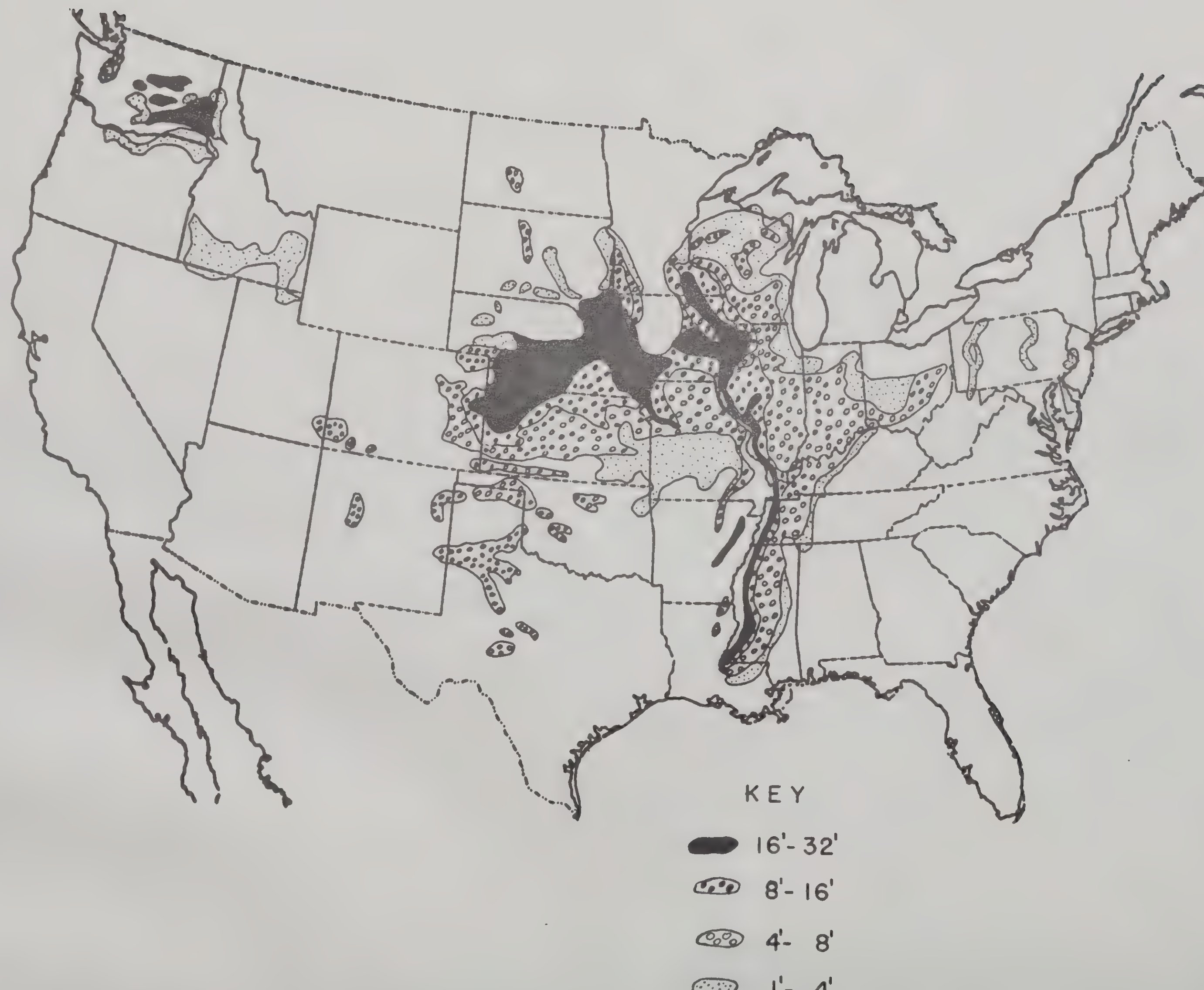
Test Plot - before leveling, view toward NW

Next year this plot will be limed, fertilized, and seeded to rye and sweetclover to reduce acidity and compaction and increase organic content, tilth, nutrient levels and water availability. The following year it will be returned to corn to determine how much improvement in growth, yield and soil characteristics was gained.



LOESS TERRACE PROJECT
VAN ZEE SITE

LOESS RESOURCES OF THE U.S.



1974 Harvest - All Values in Bushels/acre

Corrected for 25% Moisture Content
(except where noted differently)

Loess	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	Average
0"–6" loess	11.5	15.3	21.7	14.0	14.0	12.8	12.8	12.8	24.3	28.1	26.8	17.9	15.3	26.8	30.6	25.5	21.7	12.0	Row pinches out 8.4	18.6 Bu/A
6"–12" loess	14.0	30.1	24.3	Ponding of Water During Spring Here			28.1	38.3	35.7	Row pinches out 19.1	39.6	39.6	46.0	46.0	43.4	44.7	26.8	29.0	17.9	30.0 Bu/A
12"–18" loess	20.4	43.4	34.5	26.8	30.1	39.6	40.8	40.8	43.4	48.5	42.1	44.7	49.8	48.5	51.1	56.2	35.7	28.1	12.9	39.1 Bu/A
18"–24" loess	26.8	29.4	39.6	29.4	35.7	39.6	38.3	43.4	48.5	53.6	43.4	38.3	35.7	48.5	46.0	54.9	43.4	25.5	28.1	39.7 Bu/A
24"–30" loess	31.9	26.8	29.4	23.0	20.4	28.1	42.1	63.8	38.3	52.3	40.8	53.6	56.2	46.0	39.6	28.1	28.1	20.4	19.1	36.5 Bu/A
30"–36" loess	16.6	14.0	17.9	12.8 Row pinches out	17.9	21.7	21.7	26.8	34.5	28.1	31.9	29.4	24.3	24.3	20.4	23.0	21.7	17.9	16.6	22.2 Bu/A

Compaction Severe (columns A–B and R–S)

Compaction Minimal (18"–24" loess)

Compaction Moderate (24"–30" loess)

Compaction Severe (30"–36" loess)

63'

6' — 6' — 6'

Lime* — Line + Organic* — Organic* — No Treatment*

18.9 Bu/A — 31.4 Bu/A — 38.2 Bu/A — 29.4 Bu/A

Test Plot - Aver. 31.0 (25% moisture)
33.5 (21% moisture)

Loess Stripped Area Aver. 68.5 Bu/A (21.0% Moisture)

Control Plot Aver. 107.9 Bu/A (19% Moisture)

*Treatment to spoils before adding loess

Project Data

	1974	1975
Seed Corn	Funks 4444, 105 day variety	Funks 4444, 105 day variety
Date Planted	June 12	May 16
Fertilizer	100 lbs. nitrogen/acre 48 lbs. phosphate/acre 40 lbs. potash/acre	200 lbs. nitrogen/acre 50 lbs. phosphate/acre 50 lbs. potash/acre
Herbicide	Randox T, banded	Bladex, broadcast
Plant Density	17,000 plants/acre	20,000 plants/acre
Tassling Dates	Test Plot - Aug. 9 Loess Stripped Area - Aug. 5 Normal Control Plot - July 30	July 20 July 17 July 12
Length of Drough	3 1/2 weeks (July)	6 weeks (July-Early Aug.)

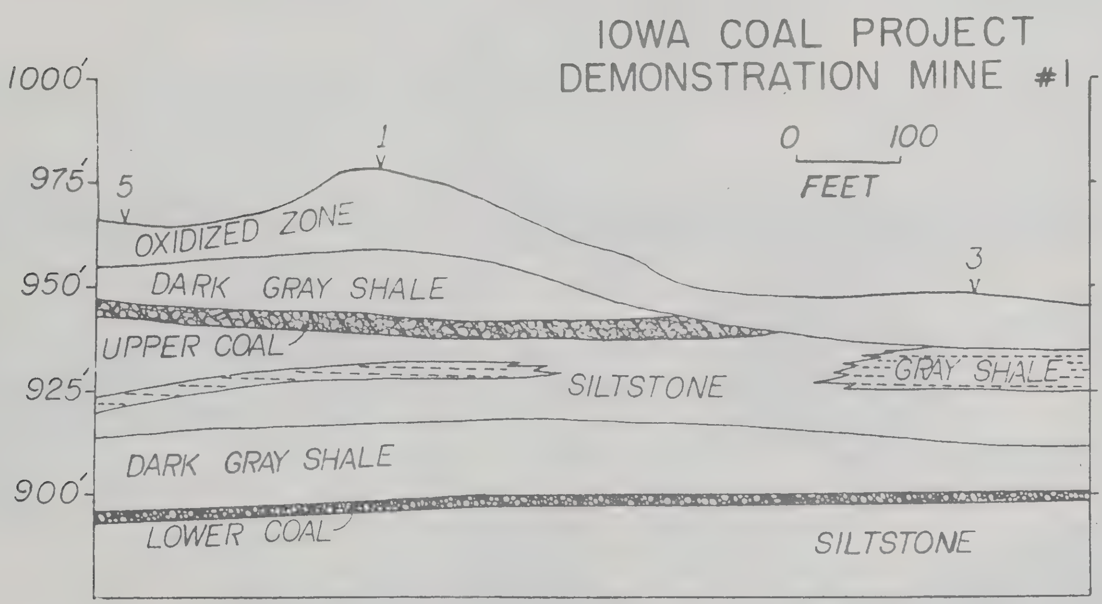
[1975 was the driest year in the area since 1956 and the next driest was 1934]

Denting Started	Sept. 16	Aug. 15
Killing Frost	Oct. 2	?
Aver. Compaction in Test Plot	3.2	2.1
Aver. Soil pH	5.8	5.2

STOP #3 - SCOTT SITE

In May 1974, the Iowa Legislature allocated $2 million to Iowa State University for a three-year coal research program to be administered by the Energy and Mineral Resources Research Insitute (EMRRI) located at Iowa State University. The legislation called on EMRRI to investigate mining techniques which would permit concurrent restoration of the land disturbed, to find economical methods of removing impurities from Iowa coal, to provide cost analyses of producing and transporting Iowa coal, and to learn if other valuable minerals could be extracted along with coal during the mining operation.

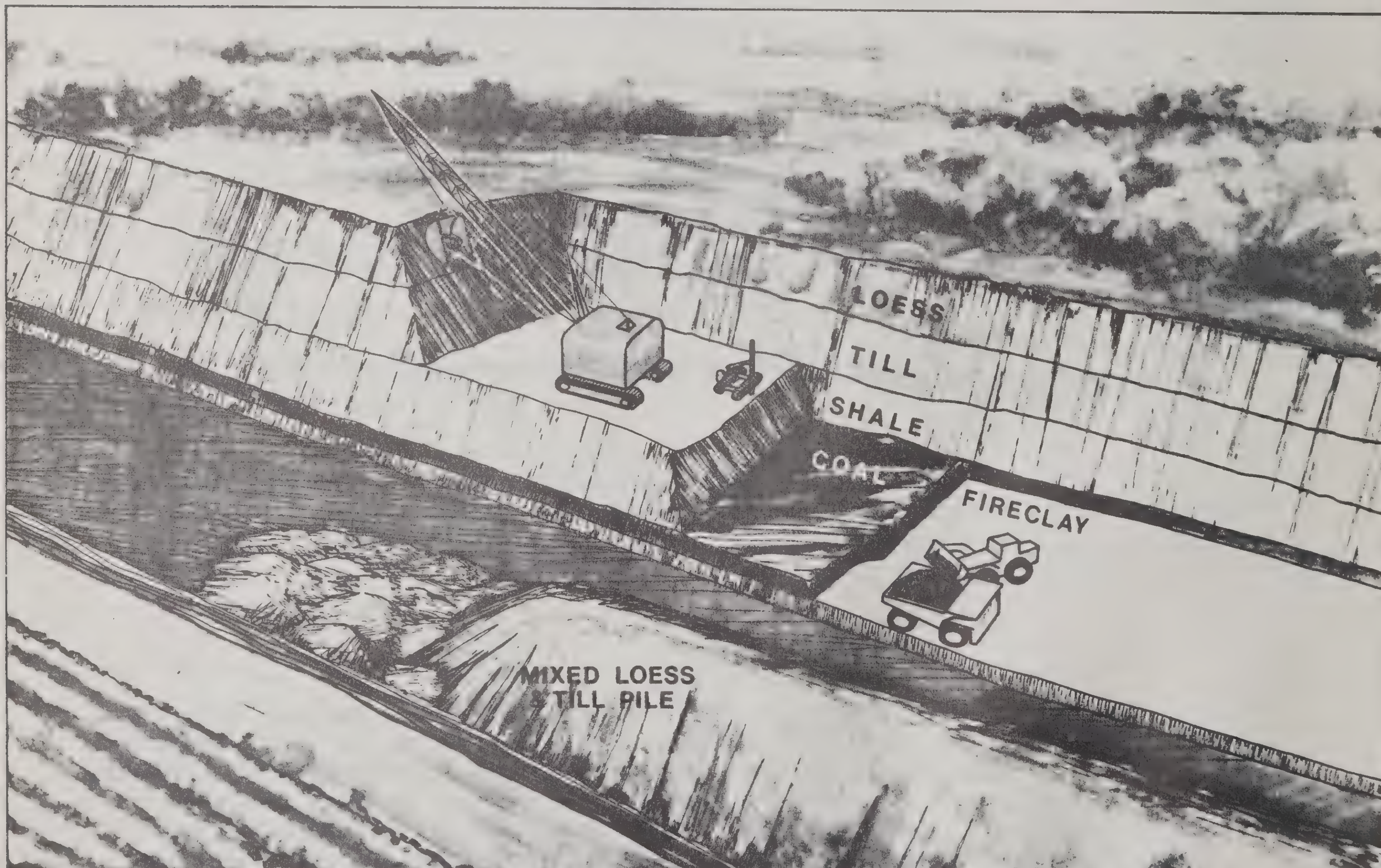
The Iowa Coal Project Demonstration Mine #1, operated under the direction of Lyle Sendein, contains two coal seams beneath the 30 acre site. The upper seam of usable coal is approximately five feet thick and covers an area of about five acres. The lower seam is about three feet thick and covers approximately 20 acres.



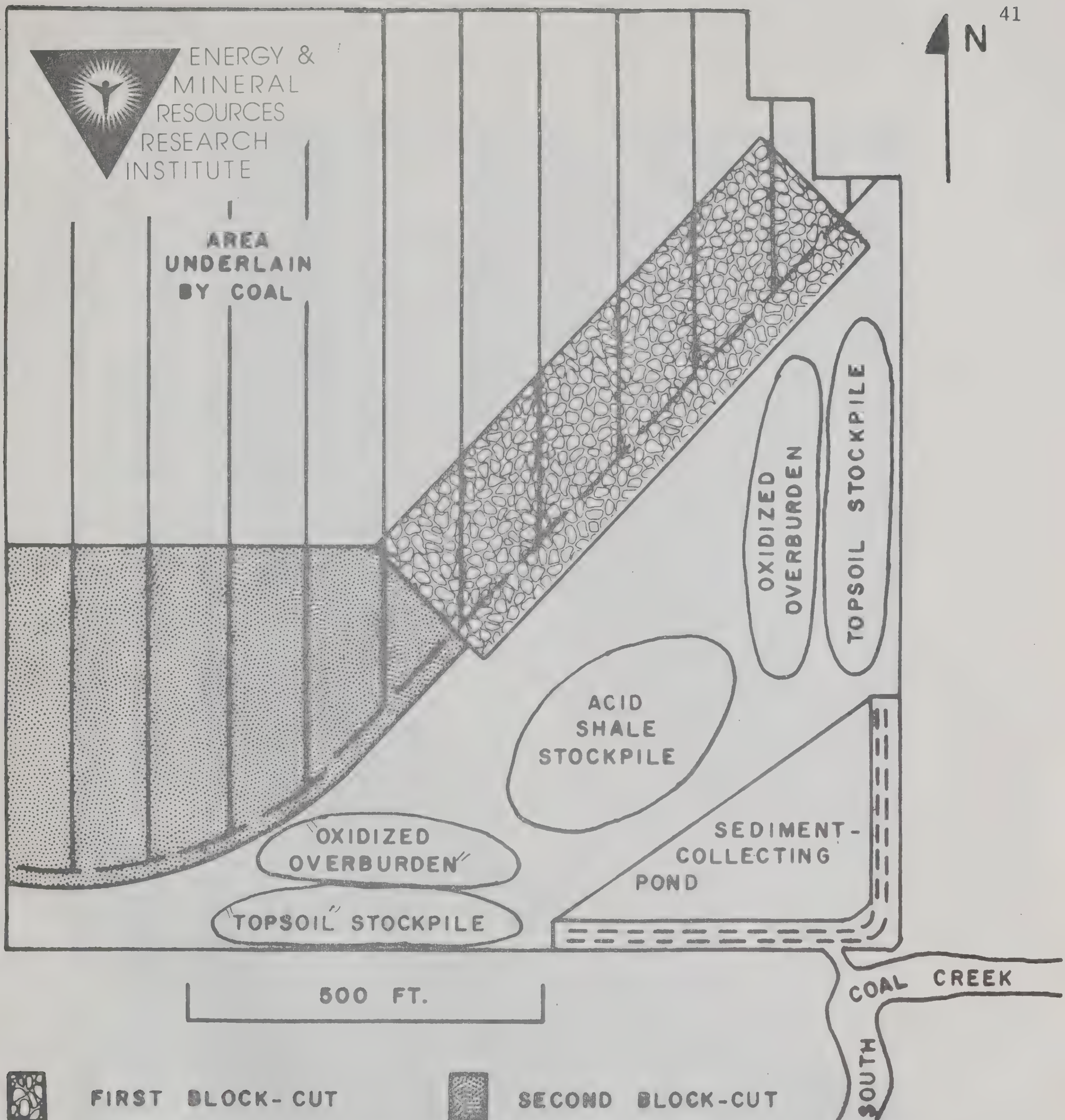
This drawing shows an east-west cross section of the mine site. The shaded strips are the two coal seams, and the numbered marks above the surface show the location of three of the bore holes. The acid-bearing layers, "dark gray shale," are just above the coal seams.

The site chosen, owned by the John Scott Estate and leased for five years by the coal project, is considered to be an excellent area for demonstration because it is located between two strip mines operated under different conditions. Nearly 1.5 million yards of overburden must be moved to mine the coal and restore the land. Approximately 135,000 tons of usable coal can be mined at the experimental site. The Star Coal Company, owned by Art Huyser of Pella, has been contracted by the project to perform the mining operations. The existing Star Mine is located directly west of Demonstration Mine #1.

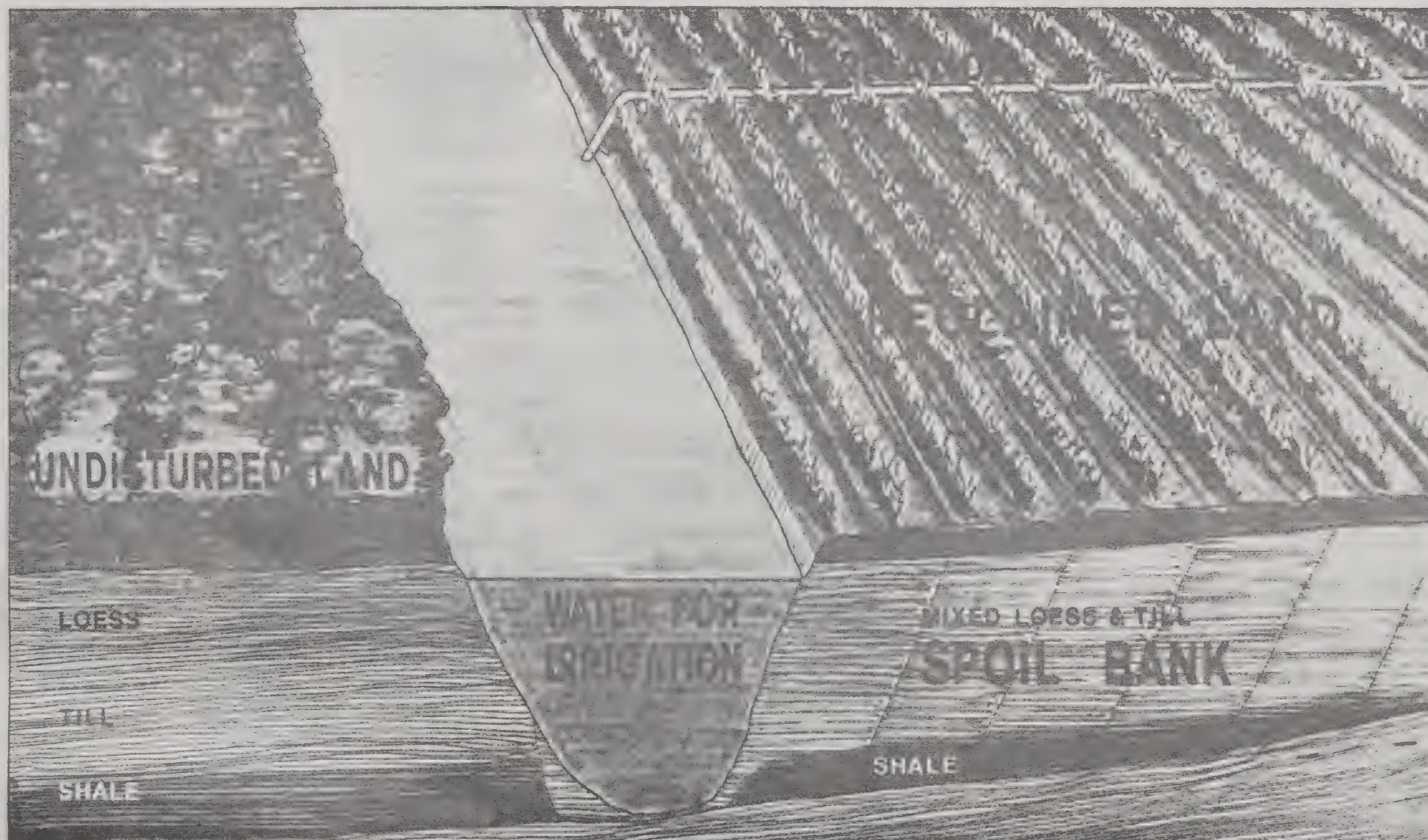
Several methods can be employed to remove and replace overburden. The choice of a particular method for the selective placement of overburden is controlled by the number and thickness of overburden layers and their physical-chemical characteristics. The block-cut method is being utilized at this site. The initial cut begins at the bottom of the slope and continues along the contour of the hill. The three layers of overburden-- "top soil," "oxidized overburden," and acid shale (just above the coal)--are being removed and stored in separate stockpiles. After the coal from the first cut is removed, a second cut will be made and the overburden from the second cut will be placed in the first pit, with the acid shale on the bottom and the topsoil on the surface. Then the coal from the second cut will be removed. This process will be repeated with each successive block of overburden moved. The final grade at the site will be a series of nearly level terraces approximately 40 yards wide separated by 10-foot high risers of 45 degree slope. An exisiting stock pond at the mine has been replaced to receive drainage water from the terraced surface. The block-cut method thus provides a convenient means to restore the area while mining is in progress. Although some mining techniques destroy great expanses of land, this method could increase the amount of agricultural land by making hilly terrain suitable for farming.



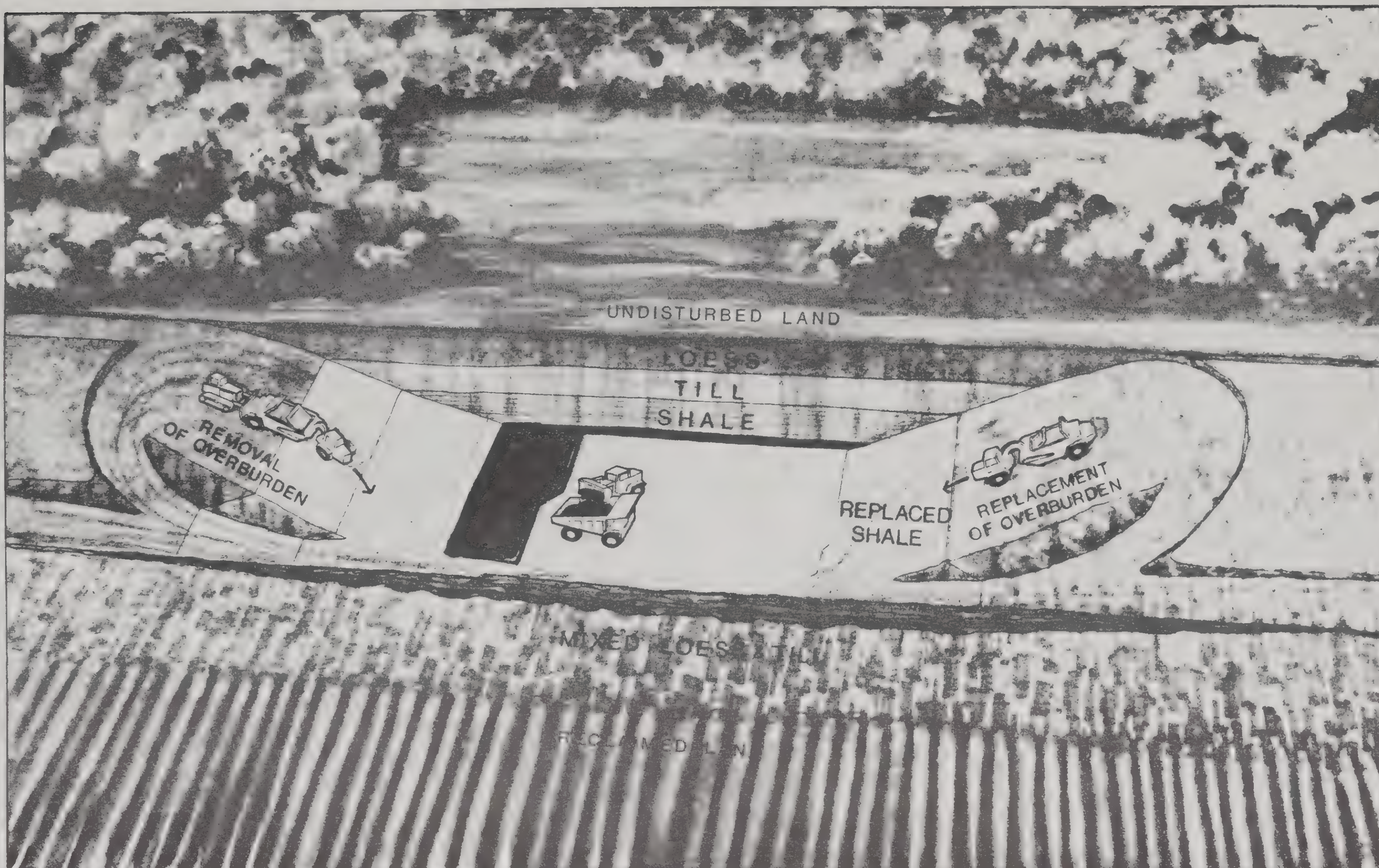
TWO STEP MINING WITH BURIAL OF SHALE



This simplified site drawing of Iowa Coal Project Demonstration Mine #1 shows where the first two block cuts will be made and where the three types of overburden will be stockpiled. The lined area is underlain by at least one of the two usable coal seams. The highest area on the site is the upper left corner, and the lowest area is the lower right. As indicated in the drawing, each block-cut will be made along the contour of the slope, and successive cuts will proceed uphill. To prevent sediments from the site from being washed directly into South Coal Creek, a sediment-collecting pond will be constructed in the southeast corner of the site.



LAND IMPROVEMENT AFTER MINING OPERATIONS



MINING BY SCRAPER

TRIP #3: ORDOVICIAN STRUCTURE AND MINERALIZATION IN NORTHEASTERN IOWA

by G.A. Ludvigson & G.R. McCormick

CONTENTS

INTRODUCTION

In 1700 the French explorer LeSueur made an expedition up the Mississippi River (now the Minnesota) in search for ore. It is generally supposed that he observed lead at several points as both Philip Bauche and M. Guettard report such finds in "Histoire L'Acadamie Royal des Sciences" in 1752.

In 1788 Julien Dubuque, a native of Canada, obtained a grant of land from the Sac and Fox tribes and began mining lead at what is now Dubuque, Iowa. Subsequent to obtaining the land grant from the Indian tribes Dubuque obtained an official land grant from the King of Spain, thus the reason for the lead mines being named the Mines of Spain. The lead ore in the Dubuque region is found chiefly as galena in vein and cavern fillings in the Galena formation.

Throughout the middle of the nineteenth century much exploration for lead and zinc was carried on in northeast Iowa and a few small mines were opened. Lead and zinc mineralization in the Ordovician rocks of Allamakee and Clayton counties occurs principally as disseminated sulfides in irregular and discontinuous carbonate veins in the Oneota dolomite and in zones of brecciated Oneota dolomite. North of Lansing, Iowa a vein 1200 feet long was found in a N-S trending fracture in the Oneota dolomite. Approximately 500,000 lbs. of galena and cerussite concentrate was produced from this mine which operated from 1893-1897.

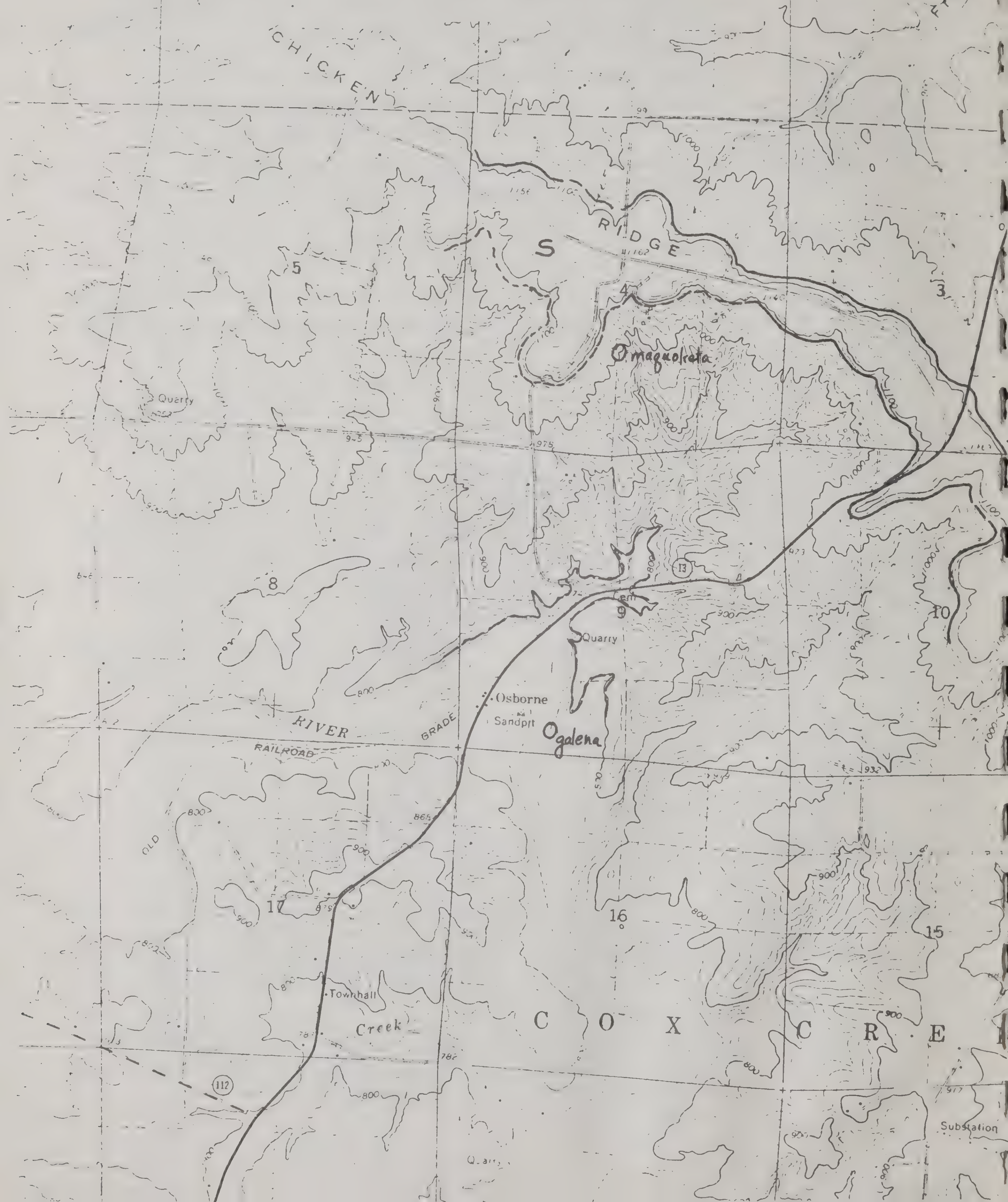
This field trip will concentrate on the lead-zinc mineralization in the Oneota formation, principally along Mineral Creek and its tributaries. Special attention will be directed to the relationship of regional fracture patterns to zones of mineralization.

MILEAGE

0	Iowa Memorial Union, Iowa City, Iowa Depart Iowa City via Route #1.
10	Solon, Iowa

16.4	At this point the valley of the Cedar River is quite wide because Cedar River is presently exhuming an older bedrock channel which crosscuts the present valley. Southeast and northwest from here the Cedar River cuts through bedrock gorges.
20	Junction of Route 30. Turn left onto Route 30.
24	Palisades Kepler State Park, Here the Cedar River cuts through a bedrock gorge in the Gower dolomite.
26.3	Junction of Route 13. Turn right onto Route 13.
34.0	Intersection of Route 151. Continue straight north on Route 13 - <u>Do not turn</u>.
37.9	Linn County Home. Turn left onto Linn Co. E-24 -- Note county landfill on left.
41.5	Intersection of Linn County W-58. Keep on E-24 - <u>Do not turn</u>.
44	Field on right contains glacial boulders strewn on the Iowan surface.
45.1	Junction of Route 150 - Turn right onto 150.
47	Duane Arnold Nuclear Plant is about three miles due west on your left. It is usually visible day and night by its thermal plume.
52	Center Point, Iowa.
57.5	Crest of the Alburnett paha - site of extensive drilling by Ruhe et al. in study of the Iowan surface. Radiocarbon date at the base of the paha (longitudinal dune) is 20,700 yrs. BP.
59.6	Town limit of Walker. Go straight - <u>do not</u> stay on Route 150.
59.7	Turn right at <u>STOP</u> sign by cafe.
60.4	Junction of W-35. Turn left on W-35 and head towards Winthrop.
67.7	Quasqueton, Iowa. Bedrock rapids can be observed in the Wapsipinican River.
68.5	In Quasqueton Route W-35 becomes Route 282. Follow 282 north out of Quasqueton.
72.2	Junction of Route 20. Turn right onto 20.
78.3	Junction of Route 187. Turn left on 187 to Lamont.
86.7	Lamont, Iowa. Continue north on Route 187.
88.1	Junction of W-51. Turn left on W-51.
89	Forrested ridge to the northeast is Backbone State Park. This is a Silurian bedrock high.
93	Junction of Route 3; Turn right on Route 3. To the northeast can be observed the dip slopes of the Niagaran cuesta.
97.8	Strawberry Point, Iowa.
98.6	Junction of Route 13. Turn left on 13 toward Elkader, Iowa.
101.5	Edge of the Niagaran Escarpment. The low lying areas to the northeast are underlain by Ordovician rocks.
107.9	Osborne, Iowa

Fig. 1 - Surveying anomalies shown on the Elkader 7 1/2' quadrangle in the vicinity of Osborne, Iowa.



Osborne Magnetic Anomaly

Early topographic maps of the area around Osborne reveal large scale surveying errors (Fig. 1) which could be accounted for by a magnetic body at depth. Wollard and Mack noted in their gravity survey of Iowa in 1950 that a gravity high was present in the vicinity of Osborne. A detailed aeromagnetic survey made over northeast Iowa in 1968 by Aero Service Corporation revealed a northeasterly trending magnetic anomaly. The most intense portion of the anomaly extends from Osborne southwesterly for 4 miles and is approximately 1/2 miles wide.

In 1961, New Jersey Zinc Company drilled and cored a hole 0.1 mile northwest of Osborne on the northeast edge of the anomaly. The drilling was initiated at 750 feet above sea level in the Prosser member of the Galena formation and passed through 1829 feet of Paleozoic section and 730 feet of precambrian rock.

The precambrian core consists of a layered ultramafic body with cyclic units of a olivine cumulate and olivine-plagioclase cumulate; the principal opaque minerals are magnetite, ilmenite, and titaniferous magnetite. The average grade of the rock in the core is 28.4% Fe and 10.3% TiO_2 which is not high enough to constitute an economic deposit at the present time.

Mr. Ken Kittleson made a detailed gravity study of the area in 1974. He identified a large gravity feature which he called the French Hollow Feature concident with the magnetic high. He further noted that the northern flank of the feature had a much steeper gravity gradient than its southern flank.

The rock body producing the Osborne magnetic anomaly and the French Hollow Gravity Feature has both a high magnetic susceptibility and density. On the basis of magnetic and gravity data together with the cumulate layered nature of the rock in core recovered from this anomaly, Kittleson interprets the anomaly to be caused by a southerly dipping intrusion of gabbro within the acidic precambrian country rock.

108.4 Contact of the Maquoketa and Galena formations.

109.7 Chicken Ridge (Fig. 1). A long southeast trending arm of the Niagaran Escarpment which has been developed by the headward erosion of the Turkey and Volga Rivers.

113 Elkader, Iowa, Old stone bridge over the Turkey River is made of Galena ls. Stay on Route 13.

121.4 Watch for traffic lights.

125.2 STOP. Junction of Routes 52 and 13 - an extremely dangerous intersection. Remain on Route 13.

126 STOP. Turn right on Route 13.

MILEAGE - continued

131	Platteville-St. Peter contact.
132.6	Junction of Route 340. Follow 340 to Pikes Peak State Park.
133.4	McGregor member of the Platteville formation.
135	STOP #1 - Pikes Peak State Park

STOP #1 - PIKES PEAK

At Pikes Peak a good overview of the stratigraphy and geomorphology of the Orodivician terrain of NE Iowa and SW Wisconsin can be observed. At the point the Mississippi Valley is cut into Cambrian Trempeleau; the top of Pikes Peak is in the Platteville fm. An excellent section from Trempeleau through Platteville is exposed along the ravine north of here leading down to the Mississippi River. The Platteville-St.Peter SS. contact here as elsewhere in the region is a normal conformable contact. The St. Peter-Prairie du Chien contact here as elsewhere in the region is not a normal conformable contact. Sand cave near the base of the ravine to the north exposes spectacular relief on the St. Peter-Prairie du Chien contact typical of the region.

Trowbridge (1917) was the first worker to publish information on the nature of the contact at this locality. He reported a maximum thickness of the St. Peter sandstone of 223 ft. underlain by just 84 feet of silicified Prairie du Chien carbonates. (Typical thicknesses penetrated in wells in the area are St. Peter Sandstone: 50 ft. and Prairie du Chien: 250 ft.). He regarded the contact here as an erosional unconformity with a maximum measured relief of 77 feet.

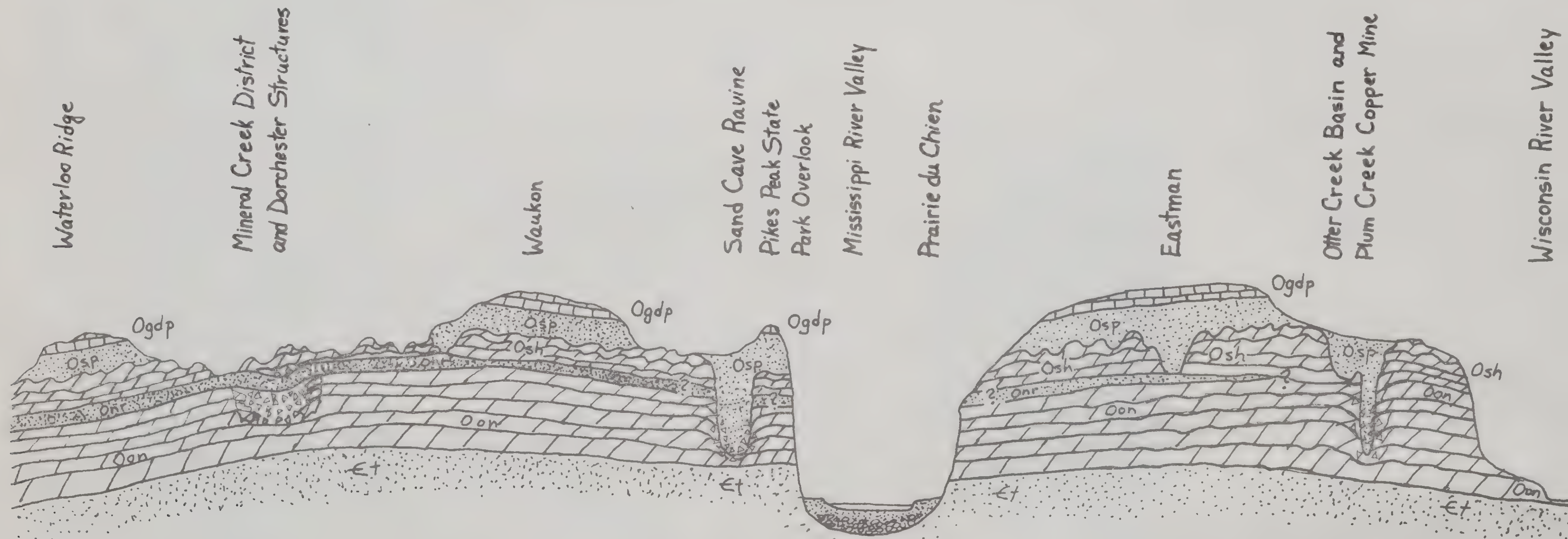
In 1955 A.E. Flint published a description of the detailed lithology of the contact zone. He reported the surface to be one of a primary irregular contact further modified by subsurface solution.

Sand Cave itself is eroded along the contact zone, which appears as an irregularly folded zone of silified white sands with discontinous "smeared" white clays. This zone is about 2 feet thick in the cave, dips at about 25°, and is overlain by "normal" St. Peter sandstone and underlain by more sands and some green shales. A short ways downstream from the cave brecciated and silified Oneota Dolomite can be seen approximately 50 feet above the stream bed and a little further beds of Oneota dolomite can be observed thinning and dipping into a "bowl" shaped depression filled by St. Peter sandstone. The brecciated and sheared aspect of both the St. Peter sandstone and Oneota Dolomite lend credence to Flint's interpretation of subsurface post-lithification movement along the contact. The problem is how much relief can be attributed to post-depositional deformation? In other localities in Wisconsin on the divide across the river, notably Otter Creek east of Eastman, mutual brecciatian, shearing and mineralization can be observed along the contact zone. At Plum Creek, copper sulfides were mined from the brecciated contact zone at the turn of the century. At those localities as well as here, the best indicator for relative movement, the Platteville-St. Peter contact, has been erosionally removed above the structures. Downward collapse of the Platteville-St. Peter contact, however, can be observed in a cut on the west side of the Franklin Township service building in Liberty Pole, Wisconsin.

Geologic investigators in this region have long noted the multisurfaced topography in the region. These features can be observed across the river on the

FIGURE 2

GENERALIZED CROSS SECTION OF THE ALLAMAKEE CO., IA. AND CRAWFORD CO., WISC. DISTRICT -GAL '75



TEXT FOR GENERALIZED CROSS SECTION

Ogdp - The Galena, Decorah and Platteville Formations, undifferentiated. Platteville Fm. caps most of the upland ridges and consists of interlayered thin-bedded limestones and shales.

Osp. - The St. Peter Sandstone. Massive large scale cross-bedded sandstone.

Osh - The Shakopee Dolomite. Dolomite with frequently occurring sand lenses and algal biohermo. Also known as Willow River Dolomite.

Onr - The New Richmond Sandstone. Thin bedded sandstone with small scale cross-bedding. Also known as the Root Valley Ss.

Oon - The Oneota Dolomite. Thick-bedded dolomite, with algal cryptozooans, bedded chert, and sand lenses.

Et - The Trempeleau Group consists of Upper Cambrian Sandstones. The upper 20 ± feet are transitional to the Oneota and characterized by calcareously cemented sandstones with steeply dipping large-scale cross-bedding.

divide between the Mississippi and Wisconsin Rivers. On the skyline is an upper surface; to its right and intermediate between the upper surface and the flood plain is another surface to the north of the Wisconsin River. Trowbridge (1921) proposed that both these surfaces be recognized as partially dissected peneplanes based on regional accordance of summits for both surfaces. The names given to these surfaces respectively are Dodgeville for the upper surface and Lancaster for the lower surface. Since that time much of the region has been mapped accurately by aerial photography allowing much better topographic control.

In 1960, E.T. Thwaites disputed much of the former evidence for peneplanation reinstating Martin's (1932) views involving simple erosional questas on gently dipping rocks and now that the term itself has grown unpopular there is generally little credence given to the peneplation theory in the development of the topography you are presently observing. Across the river at Prairie du Chien the large quarry is working in the Oneota dolomite which forms a continuous vertical escarpment to the north. Above it is an abrupt slope-break probably marking the out-crop of the New Richmond sandstone. New Richmond outcrops do not appear in the break but this is hardly atypical due to its soft incompetent character. The lowest portion of the steep slope is underlain by Shakopee dolomite and the upper portion by the St. Peter sandstone. The top of the St. Peter sandstone forms a continuous subdued escarpment that is best observed in the late afternoon during low-angle western lighting. The St. Peter sandstone is successively overlain by the Platteville formation which caps the upper surface in this region. The erosional escarpment developed on the St. Peter sandstone separates it from the lower surface which approximately marks the top of the Prairie du Chien Group. Note that Oneota dolomite outcrops in the terraces along the Wisconsin River - these are bedrock terraces and not simply Pleistocene glacio-fluvial materials that are found in many of the terraces along the streams in their lower portions in this region.

<u>MILEAGE</u> - continued

135	Return to bus and return to McGregor via Route 34.
137.3	Junction of Route 13. Turn right and follow 13 and 18 to Marquette, Iowa.
138.7	Cambrian calcareous sandstones can be seen on the left.
139.3	Marquette. Turn right on Route 76 and follow to Waukon.
142.2	Yellow River
142.5	Effigy Mounds National Monument.

MILEAGE - continued

147.5 **Fracture Zone in St. Peter Sandstone.**

Cross-bedded sandstone with apparent thin bedding due to weathering. This exposure, brilliantly iron-stained with iron oxides deposited along fractures and bedding planes can be seen on the right. Further to the east, along a generally eastward trending topographic high, the St. Peter crops out as a highly fractured grey-white quartzite, and iron mineralization can be traced eastward for at least one mile. The mineralized fractures in this expsoure trend in a northeasterly direction. (Fig. 3)

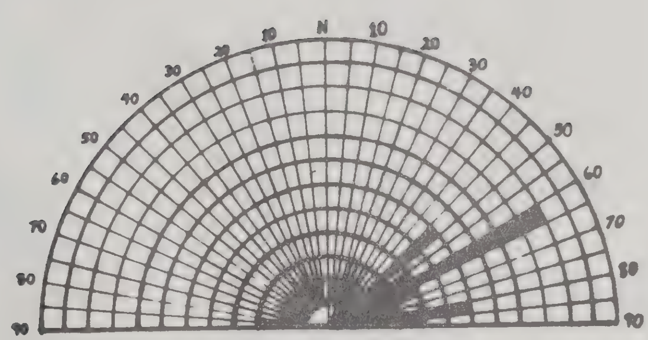
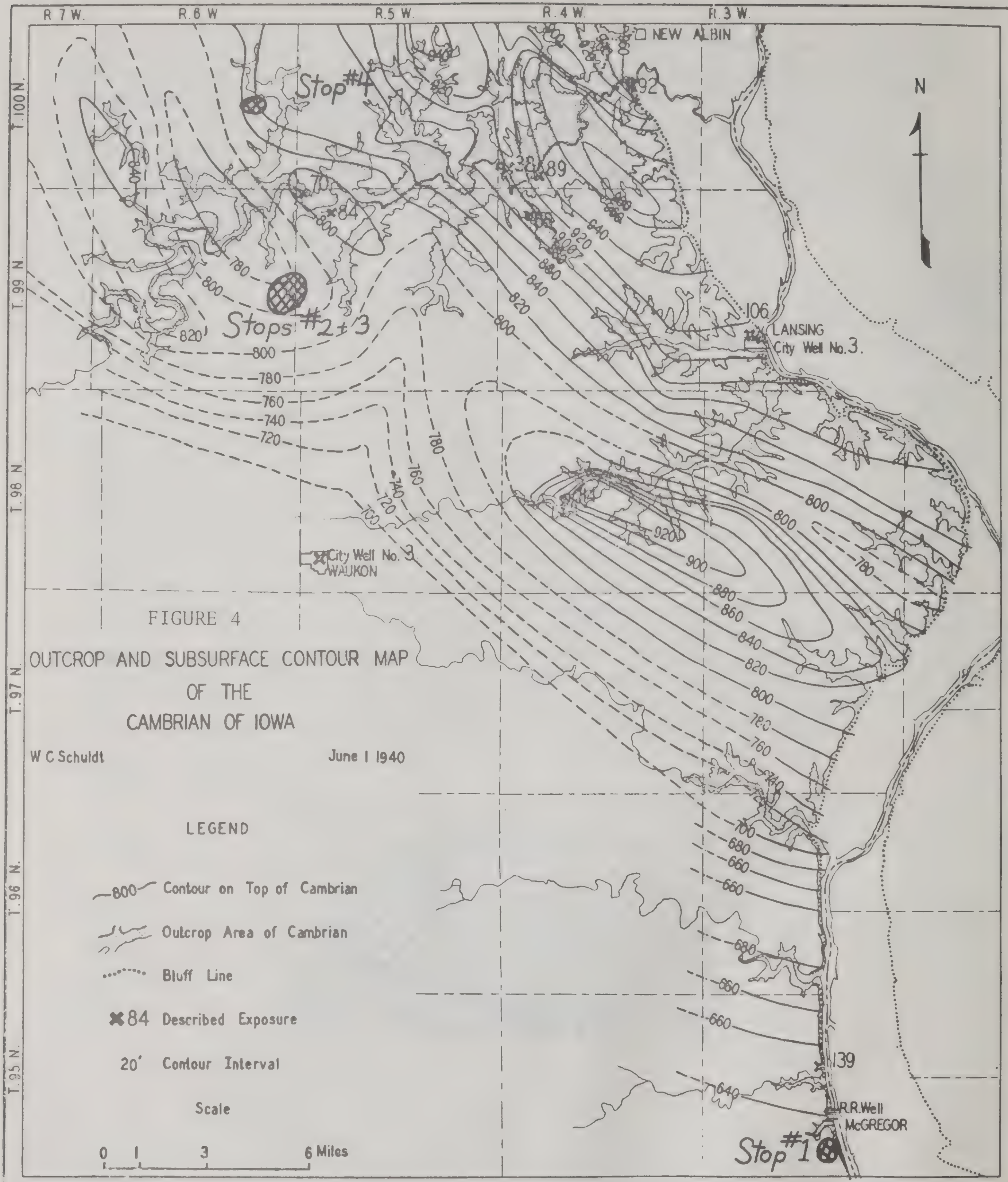


Fig. 3 - Fracture diagram for the St. Peter sandstone at mile 147.5



Reproduced from:
W. C. Schuldt, 1943, "Cambrian Strata of Northeastern Iowa"
Iowa Geological Survey Annual Report, vol.XXXVIII.

MILEAGE - continued

149.7	St. Peter sandstone.
163.7	Junction of Route 9. Stay on Route 76
164.5	Quarry in Platteville formation.
165	Waukon, Iowa. Stay on Route 76.
174.2	St. Peter-Plateville contact.
175	St. Peter-New Richmond contact.

Mineral Creek Mining District

The Mineral Creek District (Fig. 4, 5 & 6) is located on the axis of a northwest trending syncline. The sulfide deposits are located in the upper portion of the Oneota Dolomite and throughout the district seem to be closely associated with the Oneota Dolomite-New Richmond sandstone contact. Fracture maxima in and around the district show strong development of primarily northeast and east-west trending fractures. The northeast striking fractures, in particular, can be related to regional structural trends. Structure contouring of the Cambro-Ordovician contact and the top of St. Peter Sandstone show the development of a series of northwest trending folds. Assuming that these folds were created by a northeast-southwest horizontally directed maximum principal stress, the northeast trending fracture maxima can be explained by the development of extension fractures in response to that stress (Fig. 5). The structure of the ore bodies indicates that rock preparation was accomplished by downward vertical movement; the frequent occurrence of cavity fillings suggests that the ore bodies are located in collapsed cavern structures just below the insoluble New Richmond Sandstone.

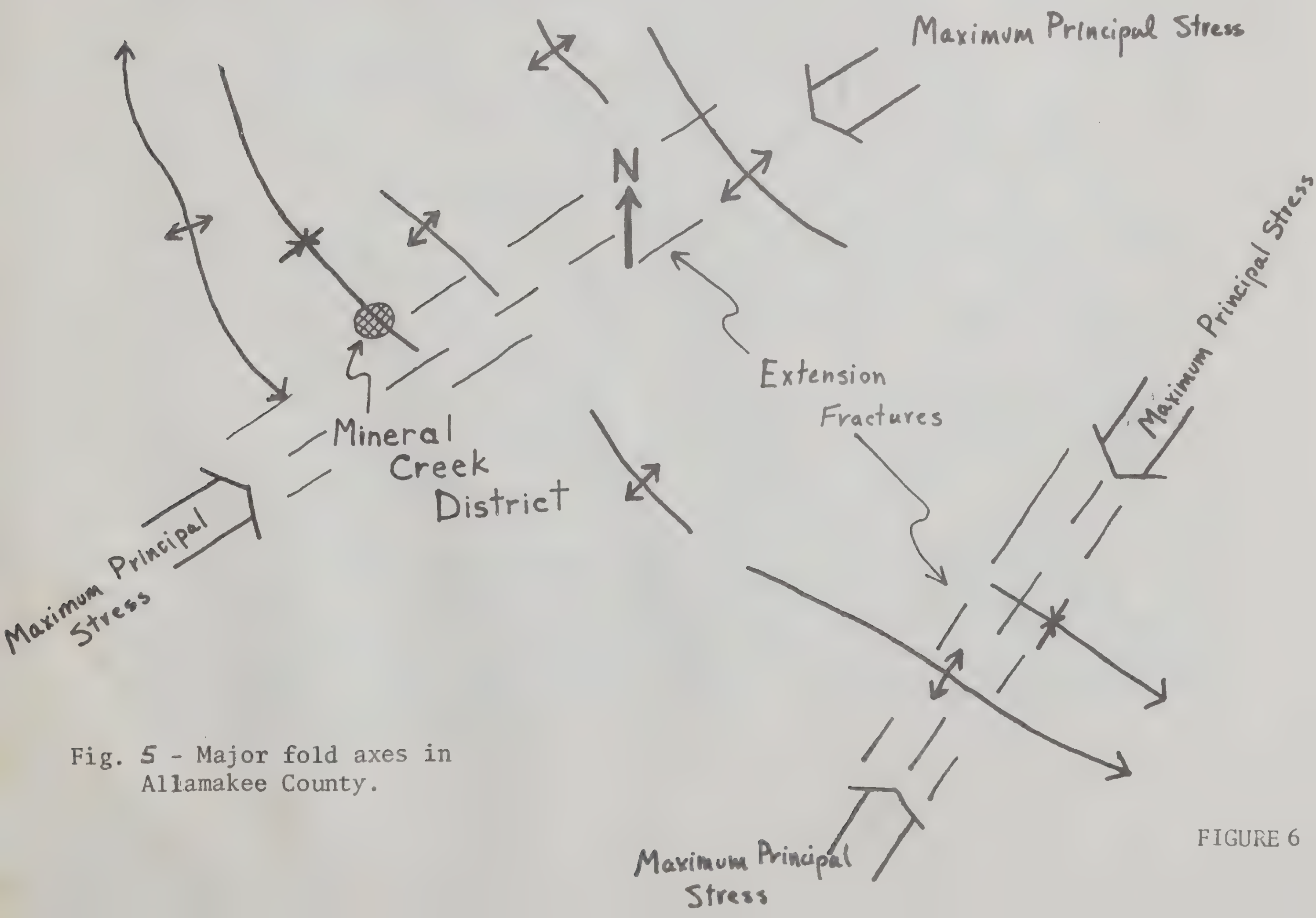
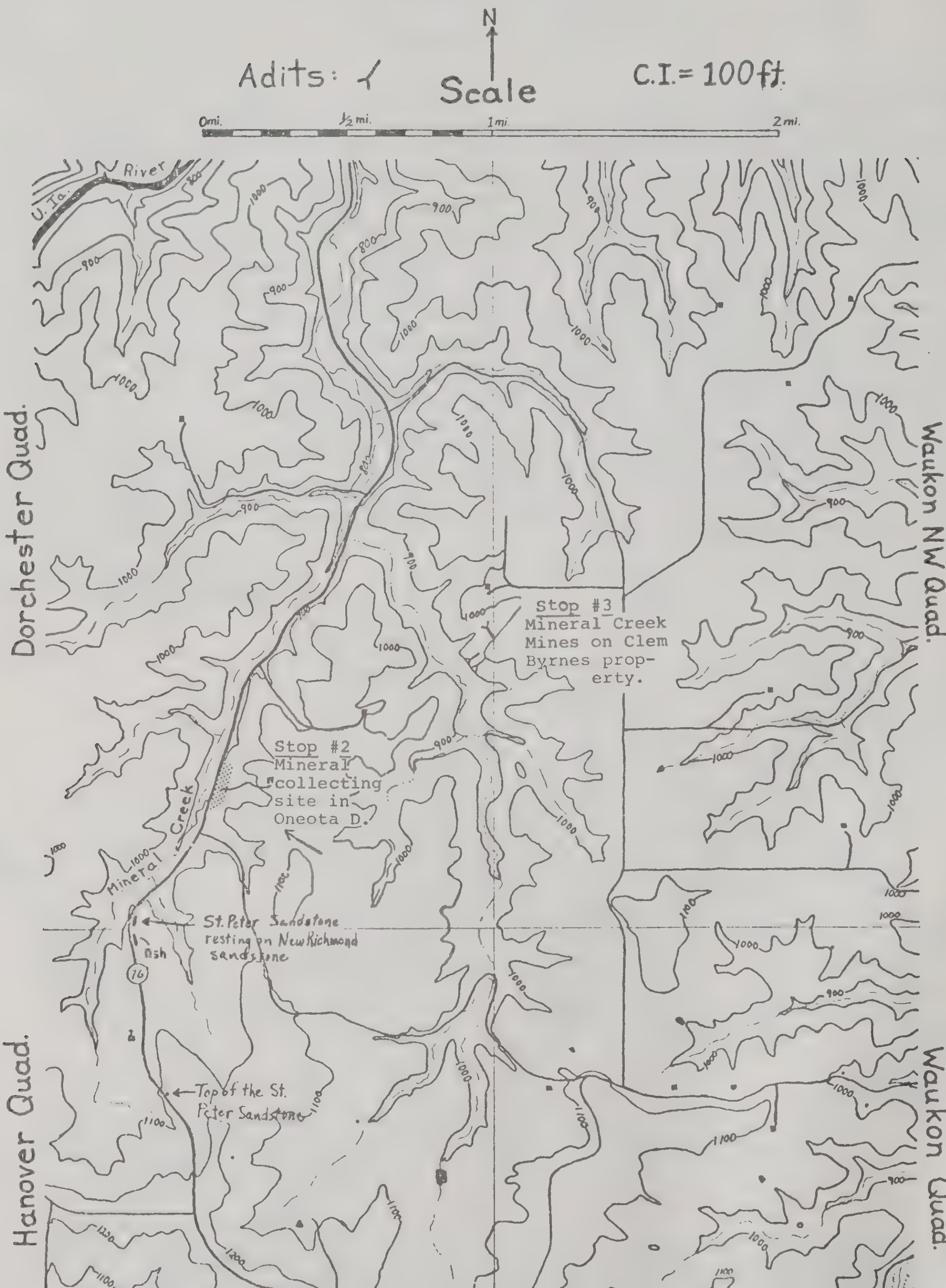


Fig. 5 - Major fold axes in Allamakee County.

FIGURE 6

FIGURE 6

TOPOGRAPHIC MAP OF THE MINERAL CREEK DISTRICT



MILEAGE - continued

175.8 Stop #2 - Mineralization in Oneota Dolomite

STOP # 2 - Mineralization in Oneota Dolomite

This outcrop exhibits the typical mineralized Oneota formation as it appears in Allamakee County. The Oneota is cut by NE trending fracture zones which contain silicified breccia of Oneota dolomite, clays, Fe-oxides, rare marcasite, calcite, and occasionally sphalerite and chalcopyrite. In the larger fracture zones can be found nice scalenahedrons of calcite exhibiting etched rhombohedral cleavage planes.

Mineralization is strongest at the fracture zones and becomes negligible a few feet from the zones. There also seems to be preferential replacement of the more dolomite rich beds along the fracture. All evidence seems to indicate that the fracture zones acted as passages for upward migration of mineralizing fluids.

175.8 Continue north on Route 76

177.1 Turn right on unmarked gravel road.

178.4 Turn right on gravel road to Clem Byrnes farm.

STOP #3 - Mineral Creek Mines

Lead deposits are scattered over at least a square mile in the Oneota dolomite at this stop. Everywhere on the surface can be found silicified Oneota breccia indicative of possible mineralization at depth. Two adits are still accessible in which galena mineralization can be observed. These adits are all that remain of the Mineral Creek mines which were opened about 1880 and were worked for approximately two years. The ore was carted to the town of New Galena which was located at the juncture of Mineral Creek and the Oneota River (now the Upper Iowa River) several miles from here. At the portal to Adit #1 will be seen a badly deformed chert bed enclosed in Oneota breccia and clay (Fig. 7). The mines themselves consist of networks of short narrow drifts which follow zones of greatest brecciation; no regular fracture system is observed. The lead is in the form of octahedral crystals of galena about 1/2 inch in diameter scattered within the edges of calcite veins. Marcasite is present within the veins and between the calcite and the wallrock; in most places the marcasite has oxidized. Fine grained reniform sphalerite occurs as small nodular masses in veins. The gangue minerals calcite, jasperiod, chalcedony, and drusy quartz have replaced much of the brecciated dolomite (Fig. 8).

In the summer of 1943 four prospect churn drill holes were drilled by Charles Youngman. No. 1 penetrated mineralized rock in which both lead and zinc combined averaged 1% as galena and sphalerite through a total thickness of 15 feet only a short distance below the New Richmond contact. Holes 2 and 3 were not sampled, but No. 4 showed 55 feet that averaged 0.25 percent zinc.

Some nineteenth century mining equipment is still scattered around the mines. Near the opening of Adit #1 two wrought iron wheels, apparently the remains of an ore cart can be seen jutting out of the rocky wash of the ravine. Upslope a cast iron and wood winch probably was used to lift the carts up to an old road grade that wound its way down to the village of New Galena three miles to the north.

Fig. 7 - A broken buckled chert bed at the opening of Adit #1 of the Mineral Creek Mines on the Clem Byrnes farm.

FIGURE 8

Mineralization Style - Mineral Ck. Mines

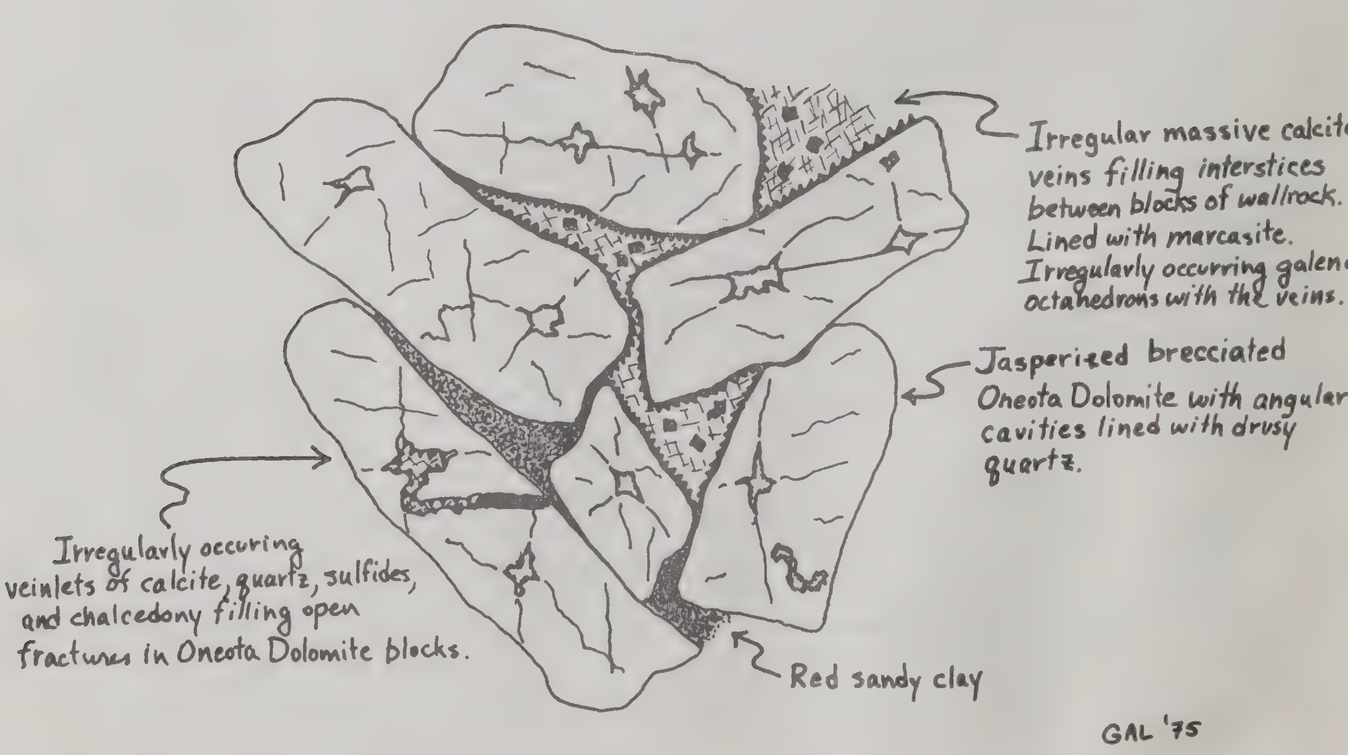
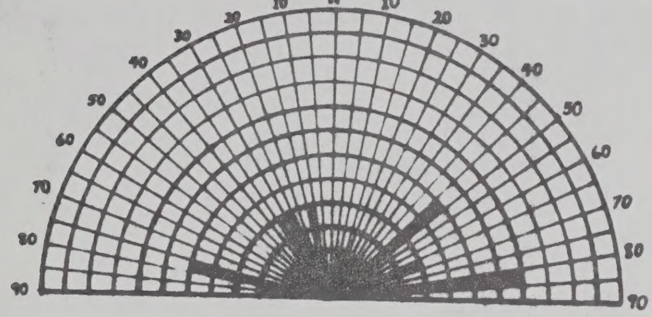


Fig. 9 - Fracture diagram from the Oneota dolomite above Adit #3 of the Mineral Creek Mines



MILEAGE - continued

178.4	Leave Byrnes farm on gravel road.
179.9	Turn left on gravel road.
181.2	Turn right on Route 76.
182	Cambrian-Ordovician contact. Madison (calcareously cemented sandstone also known as Sunset Point member) beds in contact with Van Oser member, both near top of Cambrian.
182.6	New Galena

New Galena

During the short-lived mining venture of 1880 in Mineral Creek there were hopes that an important new lead mining center was to be developed and thus the town of New Galena was established at the juncture of Mineral Creek and the Upper Iowa River. During a period of 1 to 2 years it is reported that about 100,000 lbs. of ore was taken out, however, records of the town, mining venture,

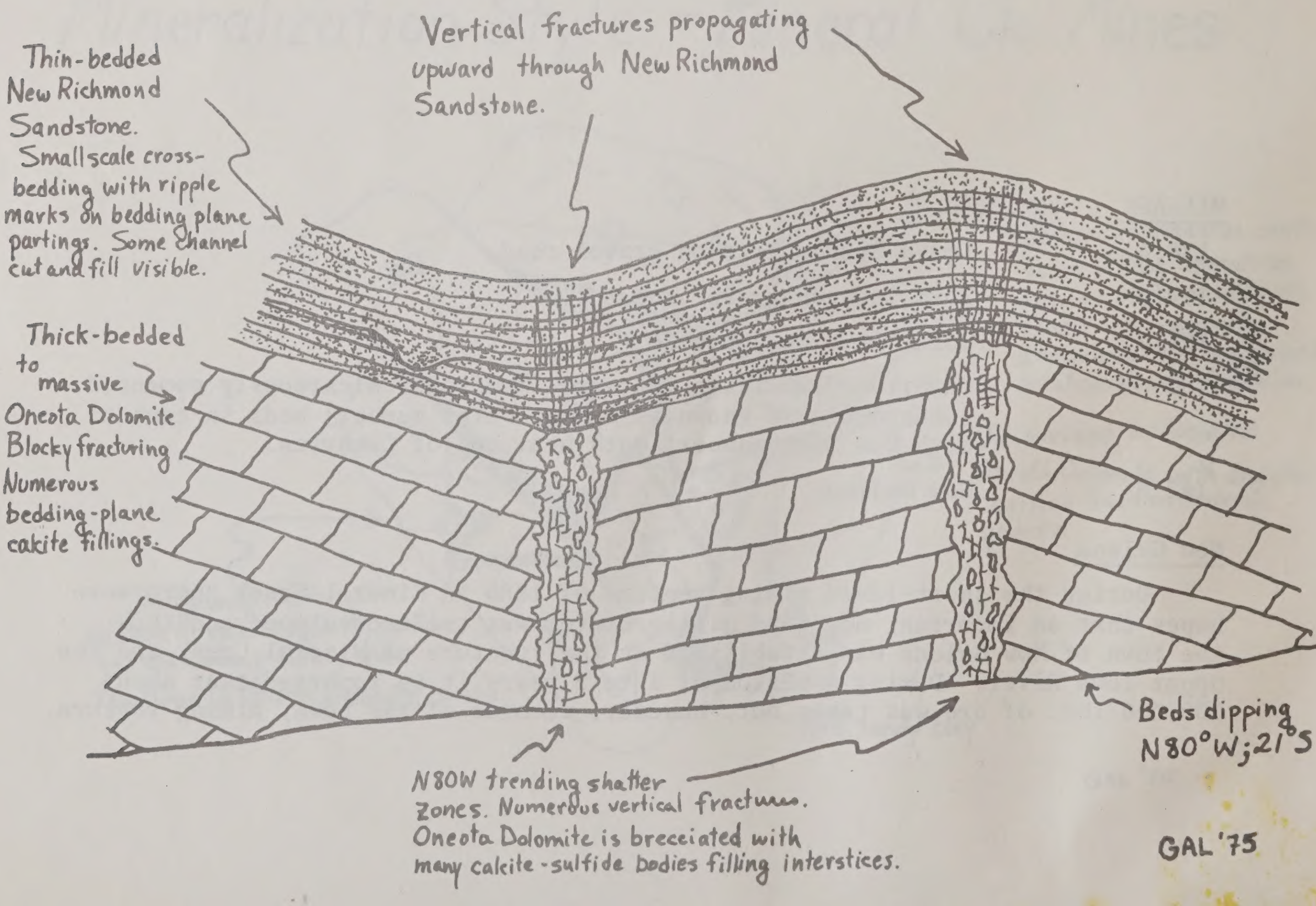
and owners are nonexistent. At first the ore was hauled to New Galena and mixed with wood in huge bonfires, the idea being that the lead would melt out. In actuality all that happened was the rock broke into small fragments and the galena had to be separated from the rock and melted down in a small smelting furnace.

The absence of continuous veins, the hardness of the jasperoid wallrock and the small size of the mineral bodies led to abandonment of the enterprise and the disappearance of the town.

185.3	Waterloo Creek
186.2	Junction of Route 119. Turn left onto 119. This is a dangerous intersection.
186.9	Dorchester, Iowa
187.3	<u>Stop #4 Dorchester Buckles</u>

Jean Young (personal communication, 1973) first pointed out this excellent example of buckling in the Oneota and New Richmond sandstone at this stop. Little, if any, folding of the beds is observed, rather the buckles are caused by differential vertical movement along N 80° W trending fractures. The fracture zones in the Oneota dolomite are highly brecciated and and contain calcite veins and Fe-oxides whereas the fracture zones in the New Richmond sandstone comprise a zone of clean breaks and no mineralization.

Fig. 10 - Buckles in the Oneota and New Richmond at Dorchester, Iowa



BIBLIOGRAPHY

Airborne Magnetometer Survey of Northeastern Iowa, 1968: I.G.S, 26 p.

Calvin, Samuel (1894), The Geology of Allamakee County; I.G.S. vol. IV, p. 37-120.

Flint, A.E. (1956), Stratigraphic Relations of the Shakopee Dolomite and the St. Peter Sandstone in Southwestern Wisconsin; Jour. Geology, v. 64, p. 396-421.

Heyl, A.V. et. al. (1959), The Geology of the Upper Mississippi Valley Zinc-lead District: U.S.G.S. Professional Paper 309, pp. 1-310.

Kittleson, K.L. (1975), A Gravity Study of the Osborne Magnetic Anomaly, Clayton Co., Iowa; Masters Thesis, The University of Iowa.

Leonard, A.G. (1896), Lead and Zinc Deposits of Iowa: Iowa Geological Survey: vol. VI, p. 11-66.

Martin, Lawrence (1932), The physical geography of Wisconsin; Wisconsin Geol. and Nat. Hist. Survey, Bull. 36, pp. 69-79.

Thwaites, E.T. (1960), Evidence of Dissected Erosion Surfaces in the Driftless Area: Wisconsin Academy of Science, Arts, and Letters, v. 49, pp. 17-49.

Trowbridge, A.C. (1917), The Prairie du Chien-St. Peter unconformity in Iowa: Iowa Academy Sci. Proc., v. 24, p. 177-182.

Trowbridge, A.C., (1921), The Erosional History of the Driftless Area; Univ. of Iowa Studies in Natural History, vol. 9, no. 3.

Wollard, G.P., and Mack, G. (1953), Gravity Map of Iowa: I.G.S., unpublished.

Ruhe, Robert V. et. al. (1968), The Iowan Drift Problem; I.G.S. Rept. of Investigations, No. 7.

IOWA CITY REGION SHOWING LOCATIONS OF STOPS FOR FIELD TRIP #1